



## **3.6 SOILS AND GEOMORPHOLOGY**

Soils are the foundation of the forested ecosystem. Large-scale land management activities have the potential to reduce soil quality or remove productive soils completely through surface erosion or physical alteration of the landscape. Additionally, soil surface erosion and landsliding (mass wasting) causes sedimentation, which affects other parts of the ecosystem, such as water quality and fish habitat.

This section evaluates effects on soils and geomorphology at a Project Area level and at a watershed level, where possible. Analysis at this level necessitates grouping soils and the effects of the proposed actions and alternatives on soils. Site-specific studies and plans are done when specific timber harvest activities are planned. THPs, required by the CDF, must address soil surface erosion and mass wasting concerns in detail.

The following sections discuss soils, the factors responsible for their formation, and the geomorphic processes that can affect soils. In addition, the impact of geomorphic processes on water quality and fish habitat is also discussed. Finally, this section discusses the way each alternative affects these geomorphic processes, which in turn affect soil, fish habitat, water quality, and to a lesser extent, wildlife habitat. Channel morphology, an important component of fish habitat, is also discussed.

### **3.6.1 Affected Environment**

#### **3.6.1.1 Geomorphic Setting**

The PALCO Project Area lies in an area of intense tectonic activity, the MTJ. Much of the area's geology is shaped by the forces of

colliding plates (see Section 3.5, Geology and Mineral Resources). The area is rapidly uplifting, due to its proximity to the MTJ. Uplift has been estimated to be up to 0.16 inches per year along the coast (McLaughlin et al., 1983), while regionally it averages between 0.02 and 0.06 inches per years.

This province is dominated geologically by the Franciscan Complex (Figure 3.5-1) which is in part responsible for the geomorphic imprint of the region. Because much of the Franciscan Complex consists of fractured, incompetent rock, the landscape includes areas of hummocky, rolling terrain with an oak woodland and partly grassy vegetation cover that are formed due to mass movement of hillslopes. The more resistant rocks form steeper, more sharply defined slopes, which tend to be heavily forested.

Within the Project Area, significant portions are underlain by younger sedimentary rocks. These include weakly consolidated sandstone and siltstones of the Wildcat Group and the Hookton Formation. These rocks tend to weather into deeply dissected terrain with small steep tributaries. The Yager Formation also underlies much of the area. Debris slides and debris flows originating in the Yager Formation tend to form broadly convex slopes.

The combination of high rainfall, rapid uplift, and highly fractured rock produces one of the highest sediment yields on the continent, excluding the effects of land management. Recent investigations indicate that heavily managed portions of

the area may have as much as 30,000 tons per square mile per year, which would be one of the highest sediment yields in the world (Pacific Watershed Associates, unpublished report, 1998). It is recognized that land and water management may increase the rate of geomorphic processes such as surface erosion and mass wasting (Best et al., 1995).

### 3.6.1.2 Soils of the PALCO Project Area

#### Soil Development Factors

Soils are continuously evolving in response to the various factors that form them, including parent material, topography, climate, vegetation, and time. A national cooperative soil survey of Humboldt County has not been completed. However, the CDF Soil and Vegetation Survey has developed soil-vegetation association maps based on aerial photographs and validation. There are wide ranges in the characteristics of designated soil types on these maps. The relationship of vegetation to soil is presented in the various maps made by the CDF (1975).

#### *SOIL TYPES OF THE PROJECT AREA*

The Project Area is underlain mostly by the Larabee, Hugo, Hely, Atwell, and Melbourne soil series (CDF, 1975). Small areas of other soil types are also present. These series are divided into many separate units, or phases, based on slope, permeability, and rock content. For this analysis, soils are presented by series.

Larabee soils are gray-brown at the surface and strong brown in the subsurface; range from 40 to 70 inches deep; and range in texture from loam to a clay loam. They are developed on soft sedimentary rocks on hilly to very steep terrain and are rated moderately erodible. Larabee soils are widespread throughout the Project Area, occurring in the Yager Creek, Van Duzen, Eel, Bear, and Mattole watersheds.

Hugo soils are gray-brown at the surface, pale-brown at the subsurface, and are 30 to 60 inches deep. They range in texture from loam to clay loam, and are derived from sandstone and shale in hilly to very steep terrain. Surface erosion hazard is moderate to high (University of California, 1979). Hugo soils are found largely in the Elk River, lower Freshwater, Van Duzen, and Eel River watersheds.

Hely soils are dark grayish-brown at the surface, brown in the subsurface, and range from 40 to 70 inches deep. They are classified as fine sandy loam to sandy loam and are developed on soft sedimentary rock. Surface erosion hazard is high to very high (University of California, 1979). Hely soils are found mostly in the Eel and Van Duzen River watersheds.

Melbourne soils are brown at the surface and dark-brown in the subsurface, 30 to 60 inches deep, and are classified as loam to clay loam. They are derived from sandstone and shale on hilly to very steep terrain. Surface erosion hazard is moderate on slopes less than 50 percent (University of California, 1979). Most of the Melbourne soils in the Project Area are located in the Eel River watershed.

While less common in areal extent, Atwell soils are important because they are extremely erodible (University of California, 1979). They are derived from graywacke sandstone and also from fault gouge (i.e., highly fragmented rock associated with shear zones). They are found primarily in the Freshwater and Bear River HUs.

#### *Soil Types by Hydrologic Unit*

The following sections discuss the dominant soil types for each HU within the WAAs. The proportions described include only the soils on PALCO lands.

#### Mad River WAA

This area is dominated by the Hugo soils. As a whole, the WAA contains approximately 62 percent Hugo soils, 9 percent Larabee

soils, 6 percent Atwell, 4 percent Boomer, and less than 3 percent of various other soil types. In the Iaqua Buttes HU the main soil types are Hugo, at 63 percent and Boomer at 11 percent. The Butler Valley HU is somewhat different, containing less than 1 percent Boomer soils, but 8.5 percent Atwell, 13 percent Larabee, and 8 percent Melbourne soils. Because of the portion of moderate to highly erodible soils in this WAA, it should be considered sensitive to disturbances.

#### Humboldt Bay WAA

The Jacoby Creek watershed contains about 50 percent Hugo and 50 percent Melbourne soils. Freshwater Creek contains the highest percentage of Atwell soils in the Project Area (14 percent) indicating a high potential for surface erosion. Most of the remaining soils in the watershed are Hugo and Larabee, with small amounts of Josephine and Melbourne. The Elk River watershed contains mostly Larabee (76 percent) and Hugo (20 percent), indicating a moderate surface erosion hazard. The Salmon Creek drainage contains mostly Larabee soils, with 22 percent Hugo soils and a minor amount of Melbourne soils.

#### Yager Creek WAA

All the HUs in the Yager WAA are very similar, containing almost exclusively Hugo soils. The North Fork Yager HU contains a minor amount of Atwell soils.

#### Van Duzen WAA

Soils are somewhat more diverse in the Van Duzen WAA. There are about eight percent Hely soils, which are highly erodible, and occur mostly in the Hely Creek watershed (111.21010). The remaining soils consist of 25 percent Hugo, 40 percent Larabee, and 17 percent Larabee gravel, which is a coarser variant of the Larabee series.

#### Eel WAA

The Eel WAA contains the highest diversity of soils of all WAAs. The Eel Delta HU consists of 19 percent Hely soils, 15 percent

Hugo soil, 52 percent Larabee soil, and five percent Melbourne soil. There are minor amounts of bottomlands (floodplain deposits) and Tonini and Atwell soils. The Lower Eel HU contains mostly Hugo and Larabee soils. The Giants Avenue HU is composed almost exclusively of Hugo soils, while the Sequoia contains only 60 percent Hugo and 21 percent Larabee.

#### Bear-Mattole WAA

The Upper North Fork Mattole watershed contains a variety of soils: 9 percent Wilder soils, 13 percent Laughlin soils, 4 percent Kneeland soils, and 1 percent Atwell soils, with the remainder composed mostly of Hugo soils. The North Fork Mattole watershed has a similar distribution, but contains a higher percent of Hugo soils, and less of the Laughlin soils. The Mattole Delta HU contains about 68 percent Hugo, 9 percent Kneeland, and 6 percent bottomlands (river sediments). The Bear River watershed contains 69 percent Hugo soils, 7 percent Wilder soils, and 10 percent Kneeland soils.

#### 3.6.1.3 Geomorphology

This section characterizes areas by their susceptibility to surface erosion and mass wasting. General geomorphic features are discussed by WAA, although some HUs within the WAAs are presented in more detail. Where available, watershed-specific information on geomorphic processes is presented.

In the SYP, a soil erosion hazard rating (EHR) has been calculated for each soil using the BOF Technical Rule Addendum Number 1 (PALCO, 1998, Appendix D). This method uses a ranking system of soil parameters related to surface erosion to calculate an overall numerical rating, which is then classified as low, moderate, high, and extreme surface erosion hazard. The resolution of SYP data (six acres) may also decrease the reliability of the EHR. However, it is the best available information on PALCO lands. The

EHR across the Project Area is shown in Figure 3.6-1.

Mass wasting in its various forms is common in the Project Area. The CDMG has mapped geomorphic features related to mass wasting for many of the watersheds in the Project Area. Six major landslide categories are depicted and described in Figure 3.6-2. Specific processes affecting landslides are discussed in Section 3.6.2.1. A composite map of the CDMG geomorphic features maps is shown in Figure 3.6-3. Sixteen of the 18 quadrangles that cover the Project Area have been completed; 25 percent of PALCO lands have not been mapped.

In general, the unmapped areas would be similar to the remainder of PALCO lands that are mapped with site-specific variations reflecting local lithology, structure, and slope. As a means to estimate the potential for occurrence in these unmapped areas, geomorphic features were extrapolated based on geology and slope. This extrapolation is not a geologic map; rather it provides a general estimate of potential features in the unmapped areas. Actual locations and distributions of geomorphic features can only be determined by mapping. Such mapping, by a state-certified geologist, would occur under the provisions of the proposed action. Table 3.6-1 shows the acreage of geomorphic features by WAA.

#### Mad River WAA

The Mad River watershed is dominated by the long central valley in which the mainstem flows. A large number of short tributaries emanate from the steeply sloping valley sideslopes. Relief is between sea level and 5,000 feet. The HUs in which PALCO lands are located include Butler Valley and Iaqua Buttes. The Butler Valley HU has geomorphic features consisting of 12 percent debris slide slopes/amphitheaters and 9 percent earth flows. The Iaqua Buttes HU contains nearly identical proportions of mass wasting features.

The erosion hazard in this area is similar to that of other watersheds. The Butler Valley HU is perhaps the most erodible watershed in the Project Area, with almost 8 percent in the high category and about 33 percent in the moderate erosion category. Within PALCO property, the erosion hazard is high, about 10 percent; 39 percent of PALCO land is in the moderate erosion hazard category. The Iaqua Buttes watershed is also highly erodible, with 5 percent high erosion hazard, and 35 percent moderate hazard. PALCO lands are notably more erodible than the basin average, containing about 11 percent high-erosion hazard and 59 percent moderate-erosion hazard.

#### Humboldt Bay WAA

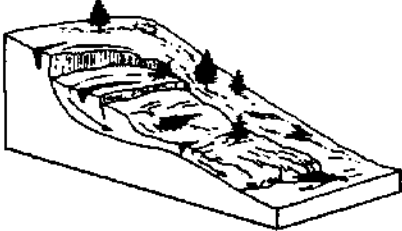
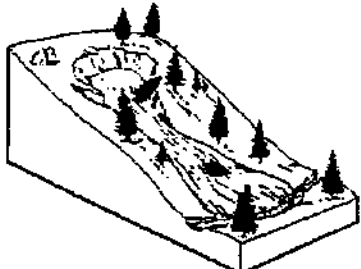
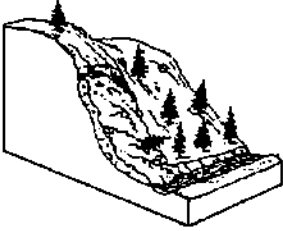
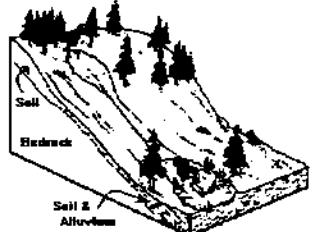
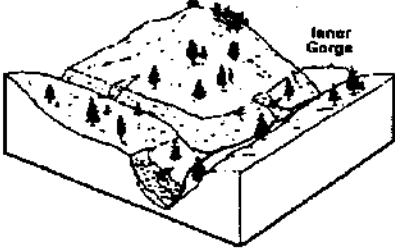

This WAA encompasses four river systems and is not based on hydrologically linked units. However, all of these rivers drain into Humboldt Bay.

Jacoby Creek and Freshwater Creek, located in the northern half of the WAA, are similar in size and geomorphic character. They have incised deeply into weakly consolidated rocks in relatively low-lying terrain. Pronounced dissection patterns have resulted, leaving short but steep valley sidewalls in the mainstem rivers and their tributaries. Tributaries have formed as a result of progressive, long-term hillslope failure. Landslide scarp faces and steep streambanks appear to persist through shallow debris slides. Only two percent of Jacoby Creek's watershed is owned by PALCO, whereas most of the headwaters of Freshwater Creek is under PALCO ownership. The EHR on PALCO land in Jacoby Creek is relatively low, with

**Figure 3.6-1. Surface Erosion Map**

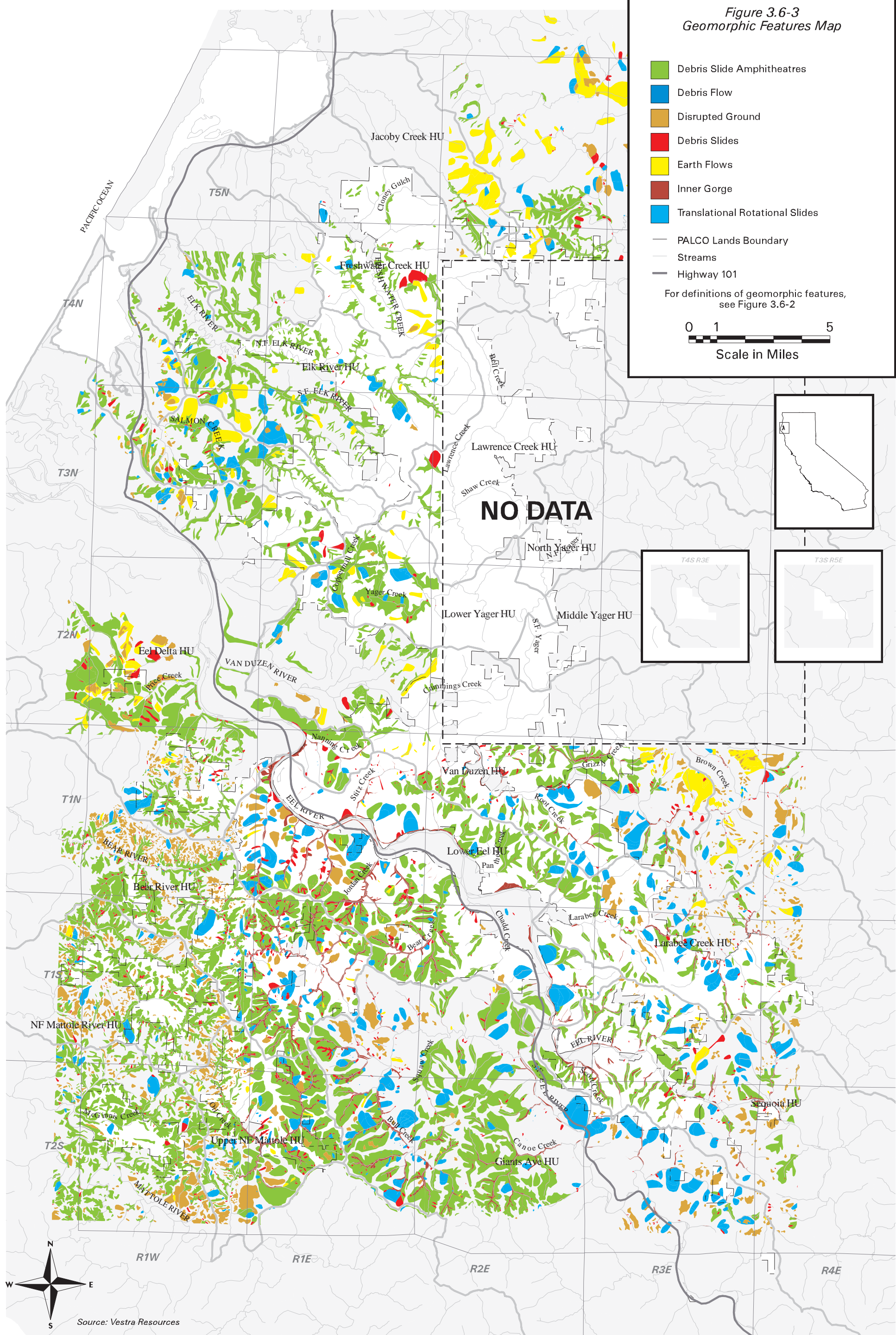
**Figure 3.6-2. Landslide Types in Northern California**

(from T.L. Bedrossian, 1983)

<p><b>Translational/Rotational Slide</b></p> <p>A landslide characterized by a somewhat cohesive slide mass and a failure plane that is relatively deep. Failure plane depth may approach 50% of the slide's greatest horizontal dimension.</p>	 A 3D block diagram showing a landslide on a hillside. A large, coherent mass of earth and rock is shown sliding down a slope. A dashed line indicates a deep, relatively flat failure plane within the slide mass. Trees are shown on the upper part of the slope and on the debris field at the base.
<p><b>Earthflow</b></p> <p>Mass movement feature resulting from slow to rapid flowage of saturated soil and debris in a semi-viscous, highly plastic state. After initial failure, the flow may move, or creep, seasonally in response to destabilizing forces.</p>	 A 3D block diagram showing an earthflow. The slide mass is depicted as a thick, fluid-like material flowing down a slope. The failure plane is curved and relatively shallow. Trees are shown on the upper slope and along the edges of the flow.
<p><b>Debris Slide</b></p> <p>Unconsolidated rock, colluvium, and soil that has moved slowly to rapidly downslope along a relatively shallow transitional failure plane. Debris slides form steep, unvegetated scars in the head region and irregular hummocky deposits (when present) in the toe region.</p>	 A 3D block diagram showing a debris slide. The slide mass is composed of loose material moving down a steep slope. A dashed line indicates a shallow failure plane. The head of the slide is a steep, bare scar, while the toe shows more irregular, hummocky deposits. Trees are shown on the upper slope.
<p><b>Debris Flow</b></p> <p>Long stretches of bare, generally unstable stream channel banks scoured and eroded by the extremely rapid movement of water-laden debris; commonly caused by debris sliding or road stream crossing failure in the upper part of the drainage during a high intensity storm.</p>	 A 3D block diagram showing a debris flow. It depicts a steep slope with a debris flow channel at the base. Labels include 'Soil' on the upper slope, 'Bedrock' at the base of the slope, and 'Soil & Alluvium' in the debris flow channel. Trees are shown on the upper slope.
<p><b>Inner Gorge</b></p> <p>A geomorphic feature formed by coalescing scars originating from mass wasting and erosional processes caused by active stream erosion. The feature is identified as that area of the streambank situated immediately adjacent to the stream, having a slope of generally more than 65% and being situated below the first break in the slope above the channel.</p>	 A 3D block diagram showing an inner gorge. It illustrates a stream channel with steep, eroded banks. A label 'Inner Gorge' points to the steep bank area. Trees are shown on the upper slope above the gorge.
<p><b>Debris Slide Slope/Amphitheater</b></p> <p>A geomorphic feature formed by coalescing scars originating from mass wasting and erosional processes caused by active stream erosion. The amphitheater is characterized by an aggregate of debris slides left by predominately unconsolidated rock, colluvium, and soil that has moved downslope along shallow failure planes.</p>	 A 3D block diagram showing a debris slide slope or amphitheater. It depicts a large, bowl-shaped area formed by multiple debris slides. The failure planes are shown as dashed lines. Trees are shown on the upper slope.

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Figure 3.6-3  
Geomorphic Features Map



**Table 3.6-1. Geomorphic Features on PALCO Lands by HU**

HU	Geomorphic Feature (Acres) <sup>2/</sup>							Grand Total
	DA	DF	DG	DS	EF	IG	TR	
Bear River	5,930	6	454	505	60	790	1,003	8,748
Eel Delta	2,384	1	38	232	104	89	311	3,159
Elk River <sup>1/</sup>	3,208	1	29	69	389	15	185	3,896
Freshwater Creek <sup>1/</sup>	1,311	1	85	215	538	2	148	2,300
Giants Ave.	2	0	13	2	0	2	123	142
Jacoby Creek <sup>1/</sup>	46	0	0	1	1	0	2	49
Larabee Creek <sup>1/</sup>	1,899	0	371	80	0	235	909	3,494
Lawrence Creek <sup>1/</sup>	2,278	3	279	256	389	207	612	4,023
Lower Eel	7,532	8	1,082	782	86	1,276	2,579	13,346
Lower Yager <sup>1/</sup>	3,620	4	177	110	278	171	0	893
Middle Yager <sup>1/</sup>	523	1	70	25	31	65	188	903
NF Mattole River	1,999	0	127	79	0	0	61	2,266
North Yager <sup>1/</sup>	513	0	36	29	65	32	0	675
Salmon Creek	677	0	0	3	7	0	19	706
Sequoia	1,942	5	95	82	9	317	349	2,798
Upper NF Mattole	3,932	9	391	225	62	364	419	5,402
Van Duzen WAA <sup>1/</sup>	5,259	5	267	217	225	352	1,262	7,588
<b>Grand Total</b>	<b>43,055</b>	<b>46</b>	<b>3,514</b>	<b>2,911</b>	<b>2,244</b>	<b>3,918</b>	<b>8,169</b>	<b>60,388</b>

HU	Geomorphic Features (Percent) on PALCO Lands <sup>3/</sup>							Grand Total
	DA	DF	DG	DS	EF	IG	TR	
Bear River	34.0%	0.0%	2.6%	2.9%	0.3%	4.5%	5.8%	50.2%
Eel Delta	23.9%	0.0%	0.4%	2.3%	1.0%	0.9%	3.1%	31.7%
Elk River <sup>1/</sup>	16.6%	0.0%	0.2%	0.4%	2.0%	0.1%	1.0%	20.2%
Freshwater Creek <sup>1/</sup>	9.4%	0.0%	0.6%	1.5%	3.9%	0.0%	1.1%	16.5%
Giants Ave.	0.3%	0.0%	9.4%	1.1%	0.0%	1.4%	86.6%	98.8%
Jacoby Creek <sup>1/</sup>	14.1%	0.0%	0.0%	0.2%	0.3%	0.0%	0.5%	15.1%
Larabee Creek <sup>1/</sup>	12.7%	0.0%	2.5%	0.5%	0.0%	1.6%	6.1%	23.4%
Lawrence Creek <sup>1/</sup>	18.7%	0.0%	2.3%	2.1%	3.2%	1.7%	5.0%	33.1%
Lower Eel	20.8%	0.0%	3.0%	2.2%	0.2%	3.5%	7.1%	36.9%
Lower Yager <sup>1/</sup>	38.0%	0.0%	1.9%	1.2%	2.9%	1.8%	0.0%	45.8%
Middle Yager <sup>1/</sup>	20.2%	0.0%	2.7%	1.0%	1.2%	2.5%	7.3%	35.0%
NF Mattole River	38.7%	0.0%	2.5%	1.5%	0.0%	0.0%	1.2%	43.8%
North Yager <sup>1/</sup>	6.0%	0.0%	0.4%	0.3%	0.8%	0.4%	0.0%	7.9%
Salmon Creek	21.4%	0.0%	0.0%	0.1%	0.2%	0.0%	0.6%	22.3%
Sequoia	16.9%	0.0%	0.8%	0.7%	0.1%	2.8%	3.0%	24.4%
Upper NF Mattole	43.9%	0.1%	4.4%	2.5%	0.7%	4.1%	4.7%	60.3%
Van Duzen WAA <sup>1/</sup>	27.9%	0.0%	1.4%	1.2%	1.2%	1.9%	6.7%	40.2%

1/ Denotes watersheds where extrapolations from unmapped areas were added to existing planning watershed information.

2/ DA = Debris slide/slope/amphitheatre

DF = Debris flow

DG = Disrupted ground: irregular ground surface caused by complex landsliding processes resulting in features that are indistinguishable or too small to delineate individually at this scale; also may include areas affected by downslope creep, expansive soils, and/or gully erosion.

DS = Debris slide

EF = Earth flow

IG = Inner gorge

TR = Translational/rotational slide

3/ Proportions of PALCO ownership within each HU are shown in Table 3.4-2.

Source: Foster Wheeler Environmental

47 percent in the low category, and 52 percent in the moderate category (Figure 3.6-1). Within Freshwater Creek, the EHR is relatively low, with 79 percent of PALCO lands in low EHR, and only 1 percent high or extreme EHR. The dominant geomorphic feature in Jacoby Creek is debris slide/slope amphitheaters, herein referred to as debris slide slopes (80 percent), followed by translational/rotational slides (9 percent). In Freshwater Creek, the predominant feature is also debris slopes, but the proportion is much less at 38 percent. Drainage density for Jacoby Creek is only 1.1 mi/mi<sup>2</sup> while Freshwater Creek has a very high drainage density of 4.17 mi/mi<sup>2</sup>. Drainage density is an indication of how close any particular site might be to a stream. The higher the stream density the more streams there are and the more likely a mapped landslide may be near a stream.

The other two river watersheds (Elk River and Salmon Creek) are approximately the same length and have similar orientation (southeast-northwest). They have very different drainage densities, however, at 4.2 and 1.7 mi/mi<sup>2</sup>, respectively. The uppermost portions of both watersheds are in the Headwaters Forest. This area is relatively gentle and is not deeply incised. As a result, there are few mass wasting features in the Headwaters Forest, with the exception of small, localized streambank failures.

Within the Elk River HU, PALCO and Elk River Timber Company own almost all of the upper four planning watersheds. The remaining 7,500 acres in the lower planning watershed is owned by other private landowners. Among the timberlands, EHR for both watersheds is relatively low, with 80 percent in the low-hazard category, and 20 percent of moderate hazard (Figure 3.6-2). The dominant geomorphic features in the Elk River drainage are debris slide slopes and

translational/rotational slides, while the Salmon Creek watershed is composed almost entirely of debris slide slopes (93 percent). Within Headwaters Forest, EHR is relatively low. The area consists mostly of two planning watersheds, 110.0030 and 110.00031, which are in different HUs. Combined, the two watersheds have about 85 percent low EHR and about 14 percent moderate EHR.

#### Yager Creek WAA

In general, the Yager Creek WAA is not as dissected as the Humboldt Bay WAA. Its valley slopes are broad and relatively smooth. Its lower section contains a nearly unbroken string of debris slides and shallow slumps along the inner gorge of the mainstem. There are relatively few tributaries. The main tributaries that make up the HUs in the area are Lawrence Creek, the North Fork, and the South Fork.

Lawrence Creek was estimated to have 90 percent low EHR. The dominant geomorphic feature is debris slide slopes (18 percent); however, this is one of the most relatively stable HUs, with only 32 percent of the land being designated as having geomorphic features related to landslides (these areas may still be significant sediment sources). The headwaters of both Yager and Lawrence creeks are in a predominantly prairie environment, in part attributable to earth flows.

The North Fork Yager Creek has 76 percent low EHR, and 22 percent moderate EHR. However, gullying in the prairie lands within the watershed is extensive, based on aerial photograph interpretation. The dominant geomorphic feature is debris slide slopes (six percent). This HU has the lowest percentage of landslide-related geomorphic features in the Project Area, at eight percent.

The Middle Fork Yager Creek HU, which also contains the South Fork of Yager Creek, is characterized by gentle slopes except near its junction with the North Fork. As with the North Fork, its headwaters are mostly in prairie indicative of earthflows. The channel of the South Fork occupies a high shallow valley in its upper reaches, then drops steeply down and to the north to join with the North Fork just below the Middle Fork. This HU contains some of the highest terrain in the Project Area, at 3,600 feet. The Middle Fork HU has only low and moderate EHR, at 93 and seven percent, respectively. The dominant geomorphic feature is debris slide slopes (20 percent). The Middle Fork of Yager Creek planning watershed contains only a small proportion of PALCO lands (three percent). Lower Yager, which is owned mostly by PALCO, contains approximately 38 percent debris slide slopes, three percent earth flows, and two percent inner gorges. These proportions are high relative to most HUs.

#### Van Duzen WAA

The Van Duzen WAA consists of a number of planning watersheds on either side of the mainstem Van Duzen between Carlotta and Maple Grove. Like Yager Creek, the Van Duzen is deeply entrenched among broad, smooth mountains. It is also somewhat drier than the Humboldt Bay WAA and contains extensive prairies and hardwood forest. The watershed is relatively large; the HU occupies a small portion of the actual watershed.

Kelsey (1980) evaluated the contribution of the various sediment sources in this basin. The study showed that small areas can be significant contributors of sediment and

may be more important than the areal extent of geomorphic features (see Table 3.6-2). For comparison, the geomorphic features in the watershed consist of 39 percent debris slide slopes followed by 12 percent translation/rotational slide. EHR is about 64 percent low and 33 percent moderate. There are 780 acres of high and extreme EHR. One planning watershed, 111.21010 (includes Hely Creek), contains approximately four percent extreme EHR soils. According to Kelsey's work, this may be significant, since 73 percent of the sediment input to the stream comes from fluvial surface erosion of hillslopes on 4.5 percent of the Van Duzen River watershed. This watershed is similar to others in the Project Area due to similar climate and topography and roughly similar geology.

On a smaller basin in Redwood Creek, Best et al. (1995) found that fluvial hillslope surface erosion accounted for only 23 percent of the sediment input to Garret Creek. In that watershed, streamside landslides were much more important, contributing 38 percent of the sediment input. The difference could be attributed to several different factors, including rock type and vegetation type.

#### Eel WAA

The Eel watershed is very large relative to the other main watersheds in the Project Area, with a total area of 3,600 mi<sup>2</sup>. Five large HUs in the WAA are Eel Delta, Larabee Creek, Sequoia, the Avenue of the Giants, and the lower Eel. Most of the PALCO ownership is located within Larabee Creek and lower Eel.

The Sequoia HU contains a small amount of PALCO land, approximately 10 percent

**Table 3.6-2.** Sediment Budget for the Upper Van Duzen Basin (525 km<sup>2</sup> for 1941 to 1975)

Budget Component	Mass of Sediment (metric tons)	Percent of Total Input
Input		
Fluvial sediment yield from hillslopes	45,509,000	73
Landsliding into main channel:		
Debris slides, debris avalanches	10,630,000	17
Earthflows	2,931,000	5
Streambank erosion, main channel:		
Melange bank erosion	426,000	1
Flood plain and fill terrace erosion	2,619,000	4
Storage		
Aggradation in main channel	10,601,000	—
Output		
Total sediment discharge out of basin	51,036,000	—
Source: Kelsey, 1980		

located in the two lowermost planning watersheds. In addition, there are two isolated parcels for which no EHR or geomorphic mapping were done. PALCO owns most of the land in the Lower Eel HU.

Within the Lower Eel HU, several tributaries are located within highly unstable areas, especially Stitz Creek. This planning watershed (111.12020) is intensely dissected, probably due to the underlying shear zone (see Figure 3.5-1).

Within the same general area, a large debris flow emanated from harvested PALCO land on the ridge between Twin and Jordan creeks in the early 1997, destroying several homes in the community of Stafford. The HU has a relatively high proportion of erodible soils, with 3 percent in the high and extreme categories, and 41 percent in the moderate category. Planning watershed 111.12020 is highly erodible, with 5 percent in the high and

extreme category, and 53 percent in the moderate category. The predominant geomorphic feature is debris slide slopes followed by translational/ rotational slides.

The Avenue of the Giants HU contains less than five percent PALCO land. Data on geomorphic features or surface erosion is not available for most of these lands. The land that has been classified is 81 percent low EHR, and is almost entirely (86 percent) translational/rotational slide. The HU as a whole is broadly similar to the Sequoia HU.

The Eel River Delta HU is the lowermost HU within the WAA. It is composed primarily of the floodplain and delta, with small portions in the headwaters of Nanning Creek (111.11010), Strong Creek (111.11020), and Howe Creek (111.11011). This is where the PALCO ownership is located within the HU. In these watersheds, the proportion classified as extreme EHR is relatively low at

0.04 percent. The exception is Nanning Creek, which has 13 percent classified as extreme surface erosion hazard, the highest of all planning watersheds within PALCO ownership. The predominant geomorphic features within PALCO ownership within the HU are debris slide slopes and translational/rotational slides. It has the second highest proportion of debris slides at 2.3 percent.

Larabee Creek has most of the PALCO ownership in its lowermost study areas. The PALCO ownership within the HU is classified as 72 percent low EHR, and three percent high and extreme EHR. The predominant geomorphic feature is debris slide slopes, followed by translational/rotational slides. Much of this HU is in prairie or hardwood forest.

A study by Brown and Ritter (1971) estimated the contribution of sediment from each reach of the river. Approximately 68 percent of the annual sediment yield was determined to come from the middle sections of the Eel, between Dos Rios and the junction with the South Fork. PALCO ownership is mostly downstream of this junction.

#### Bear-Mattole WAA

This WAA, which comprises two separate watersheds, is dominated by low mountains of the Coast Range that are deeply dissected. Most slopes are moderate to steep (BLM and FWS, 1981); less than 20 percent of the area has gentle slopes. Local relief is typically between 1,000 and 3,000 feet. North of the Mattole River, the land consists of east-west trending ridges. These ridges effectively block coastal fog from significant intrusion landward. To the south, the watershed is dominated by the King Range, with elevations up to 4,000 feet; the headwaters of the Mattole are found here. Three HUs contain most of PALCO's land on the Bear Mattole WAA and the North Fork Mattole, Upper North Fork Mattole, and Bear rivers.

The Mattole River watershed has surface erosion and sedimentation on a scale similar to the Eel River watershed. Sheet and gully surface erosion, streambank surface erosion, and landslides contribute approximately equally to sedimentation (BLM and FWS, 1981; Mattole Restoration Council, 1995). Sediment production from landslides in the watershed, 0.8 acre-feet per square mile per year, is the highest in all of northern California. The high surface erosion rate is not surprising, given that the watershed is being uplifted by 6 to 10 feet every one thousand years (Merritts and Vincent, 1989).

The distribution of geomorphic features and EHR is in concordance with the high rate of sediment production. On the North Fork Mattole, the main geomorphic feature is debris slide slopes (38 percent); the EHR is eight percent extreme or high and 47 percent moderate. On the Upper North Fork, the main geomorphic feature is debris slide slopes (44 percent), followed by disrupted ground, inner gorges, and translational/rotational slides (each about 4 percent). The EHR is 14 percent extreme and high and 49 percent moderate.

The Bear River, which flows to the west out of the Monument Ridge area, is much smaller than the Mattole but similar in dissection and topography. Analysis of aerial photographs between 1941 and 1988 showed very few landslides in the areas that were not harvested. In 1988, many landslides associated with roads were still evident in areas that were harvested. Most of these landslides were associated with roads. The Bear River has a 15 percent extreme and high EHR and 43 percent moderate EHR, making it the most erodible HU in the Project Area. The dominant geomorphic features are debris slide slopes (34 percent) and translational/rotational slides (5.8 percent). As in the Mattole River watershed, the Bear River watershed is rapidly uplifting, at a rate of 10 to 13 feet per thousand years (Merritts and Vincent, 1989). This uplift rate probably contributes

greatly to the erodibility of this watershed, along with the presence of a shear zone associated with the MTJ.

#### 3.6.1.4 Timber Harvest Practices

Timber harvesting has occurred since the first Europeans settled in the Project Area during the 19th century. The techniques and equipment for harvesting timber have changed substantially over time, so the landscape of forested areas is now a complex mosaic that reflects the effects of various periods of logging. Establishing a direct cause-and-effect relationship between specific timber harvest practices and impacts on the watershed is difficult because of the effects of prior activities. Therefore, it is useful when evaluating potential impacts of timber harvest under current conditions to review the methods used in the past and how they have cumulatively shaped the hillsides and valley bottoms of the Project Area. A review of timber harvest techniques used in the redwood region of California is given in Mount (1995) and Best et al. (1995).

Timber harvest in the Project Area began with relatively simple, non-mechanized techniques at a fairly low rate of harvest. The location of logging depended primarily on ease of access and proximity to commerce centers and transportation routes. River flats and adjacent slopes were clearcut using livestock and manpower. Around the turn of the century, steam-powered engines (steam donkeys) were used to drag logs to collection areas, from which the logs were moved by train. Little regard was given to the processes of erosion and mass wasting; virtually no protection was given to fish or fish habitat. In the process, many trees were knocked down by the dragging of other logs, and deep furrows were made by dragging the logs long distances across hillslopes.

One of the most significant effects of this type of logging was from the trains

themselves. Many times, streambeds and/or the valley bottom were used as the route for the trains. Removal of LWD from streams, combined with extensive filling of the channels to make an even grade for the tracks, caused heavy damage to the streams. Oxen logging during this period produced some surface disturbance as logs were dragged to the streams. Where trains were not used, a common practice was to construct "splash dams," where streams were dammed temporarily, logs were placed in the water, and then the dams were dynamited, sending a torrent of logs, debris, and water downstream. The resulting flood surge caused extensive damage to streams and riparian areas because of their power, debris, and widespread use. Much LWD was removed by this process. Some streams may still be recovering from these activities.

By the mid-1930s, logging tractors and trucks were used in the area. Since cutting all the trees was no longer economically favorable, many operations cut only the biggest and best trees, leaving some standing. While the use of trains diminished, the effects of heavy equipment on the highly erodible hillslopes created widespread gulying and mass wasting.

In the 1950s, FPRs calling for seed trees to be left and the continued practice of high-grading resulted in a mixture of clearcutting and selective cutting. In the 1960s, more regulation of forestry began with the requirement for THPs. THPs were created to change or substantially modify the damaging timber harvest practices, and to take into consideration sensitive aspects of each harvest area. During this time, use of tractor logging increased and timber harvest rates increased dramatically, creating widespread disturbances across entire watersheds.

In the 1970s, cable-yarding techniques became more prominent, although clearcutting remained the dominant

silvicultural practice. After passage of the Z'berg Nejedley FPA of 1972, more detailed and restrictive FPRs were developed in response to the increased understanding of disturbed watersheds and related effects. These practices cover road construction, seasonal activities, silvicultural prescriptions, watercourse and lake protection, site preparation, fire protection, and other rules applicable to specific regions and counties. These practices are enforced by CDF.

Rules about cable and tractor yarding systems have changed considerably since the FPRs were first published. These changes were developed in response to research and observations from site inspections. Many of the most damaging practices have been severely curtailed or eliminated. For instance, the FPRs require the removal of skid trail crossings of streams before the rainy season begins. In addition, formal THPs must be submitted for each area proposed for logging. Much of the FPRs describe the minimum requirements of THPs.

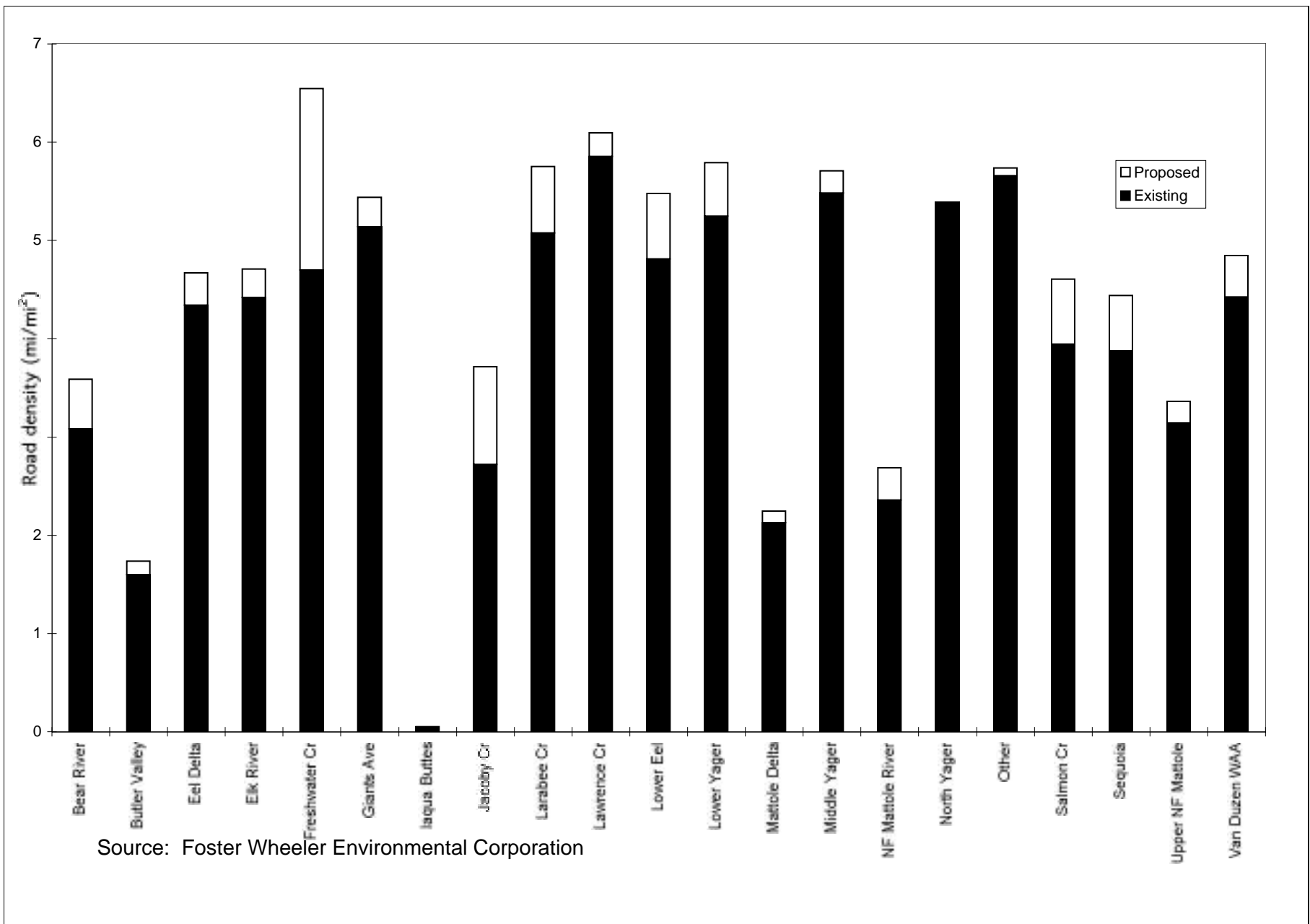
THPs are developed by an RPF, whose scope of knowledge must include all aspects of silviculture, plus environmental effects of timber harvest and road building. THPs contain detailed information on timber harvest methods, unit layout, site geology (including landslides), and waterbodies with class designation and buffer layout. THPs also address wildlife habitat concerns and cumulative effects. The THP is submitted to a review team of foresters, geologists, biologists, and water quality specialists from various state agencies. A site visit by some or all of the team members is typically conducted, after which comments are submitted to the RPF. When CDF determines that comments have been adequately addressed, the THP is approved and logging may proceed.

### 3.6.1.5 Roads

Roads are an important factor in landscape impacts related to timber harvest. Cederholm and Reid (1987) showed that in the Clearwater watershed in the Olympic Peninsula, Washington State significant increases in fine sediment occurred in watersheds with greater than about 2.5 miles of road per square mile. This study was based on conditions prior to the early 1970s and was one impetus for the improved road standards and associated BMPs developed later. Best et al. (1995) found substantial impact to hillslope surface erosion with 1.12 mi/mi<sup>2</sup> of roads. This sediment production occurred predominantly from stream diversions caused by plugged culverts (68 percent) and from failure of road crossings (12 percent). Because roads can be a major source of sediment, the miles of road per unit area (i.e., road density) provides a crude estimate of the potential condition of a watershed. The road densities of the Project Area watershed analysis units are presented in Figure 3.6-4. These numbers do not include skid trails. Seven HUs have road densities higher than 5 mi/mi<sup>2</sup>, and only two have road densities under 2 mi/mi<sup>2</sup> (Figure 3.6-4).

Skid trails can also affect sediment influx to streams. However, skid trails are not used continuously, do not cross streams, have drainage mitigation, and become overgrown after timber harvest. Consequently, skid trails are usually a lesser concern despite their large number (see Section 3.6.3.5).

While a program of road maintenance and drainage modification has begun in the Project Area, most logging roads remain susceptible to road crossing failure, particularly older roads built under different standards. In addition, there is generally a lack of road surfacing.



**Figure 3.6-4.** Existing and Proposed Increases in Road Density on PALCO and Elk River Timber Company Lands, First Decade of HCP

When heavy trucks drive on the road surface, gravel surfacing is ground into the road, and fine sediment from the underlying soil is forced to the surface. Thus, if road surfacing is not maintained, the road-generated sediment may approach pre-surfacing levels on roads with high traffic levels. The road system in the Project Area is shown in Volume 5, Map 8, in the PALCO HCP/SYP (1998). Approximately 36 percent of roads are rocked. CDMG notes that road rock in area is generally of low abrasion resistance and may break down (Personal communication, T. Bedrossian, September 1998). FPRs require that during the wet season, only rocked roads be used. Limited field reconnaissance indicates that surfacing on some mainline roads has deteriorated from use.

### 3.6.2 Impact Mechanisms

Environmental effects related to timber harvest are associated with vegetation and ground disturbance. These actions can accelerate or alter geomorphic processes. These processes are discussed below as impact mechanisms.

A complex set of interrelated processes combine to result in compound effects from land management. Figure 3.6-5 shows the interaction of timber management activities and geomorphic processes. The individual processes, along with effects on soil productivity, are discussed in the following sections. The interactive effects between processes are discussed in Section 3.6.6, Cumulative Effects.

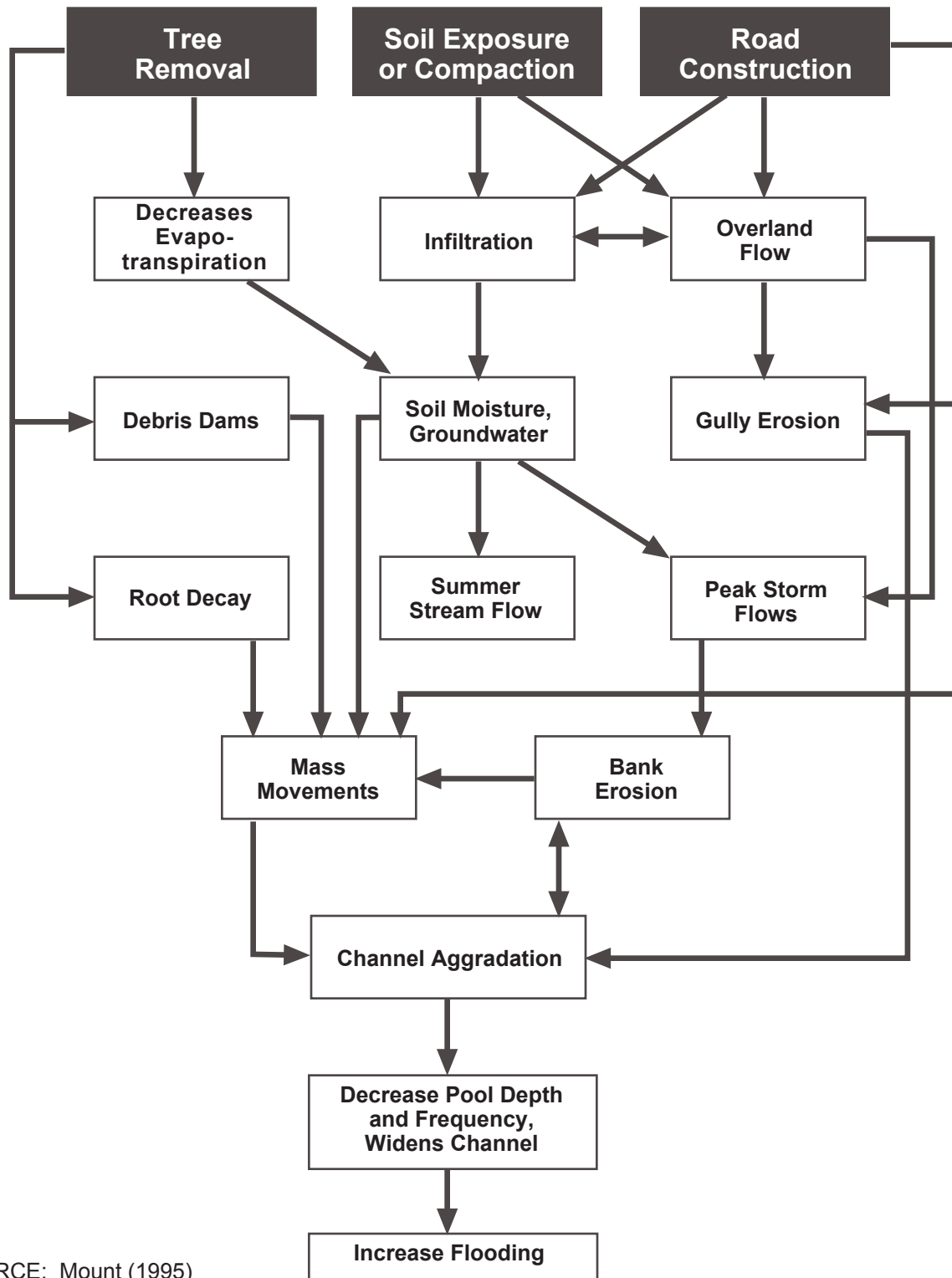
#### 3.6.2.1 Mass Wasting

Erosion in the Coast Range province of northern California is dominated by mass movement processes. Mass movement is translocation of material by the force of gravity as opposed to movement of material by water. The six categories of landslides identified by the CDMG are described in Figure 3.6-2. The Franciscan Assemblage contains rocks which are inherently weak

and are subject to large, deep-seated failures. More-resistant rocks of the Franciscan Assemblage are subject to a different form of mass wasting. These consist of shallow, rapid landslides, which originate in the thin layer of colluvium and weathered bedrock on steep hillsides. Geologic and geomorphic mapping indicates that this is also the case in the five WAAs in the Project Area (CDMG, 1982, 1983a, 1983b, 1984a, 1984b, 1984c, 1985a, and 1985b).

#### Deep-seated Landslides

Of the CDMG landslide types, deep-seated landslides include earthflows and translational-rotational slides. Earthflows and translational rotational landslides are distinct types of deep-seated landslide failures. Each has different characteristics, modes of failure, and management prescriptions. Deep-seated landslides move at a wide range of speed, about 0.2 feet per year to 4.9 feet per day (Kelsey, 1987). Often, these landslides are sparsely forested. This is in part because trees have difficulty getting established on moving soil. Movement is triggered by seasonal moisture accumulation in the soil, which increases pore water pressure and decreases the strength (effective stress) of the soil. Major episodes of movement coincide with significant rainfall events. In addition, removal of the base of an earthflow by a stream (or a road) decreases the lateral support for the block of earth, and contributes to its movement. In the upper Van Duzen watershed, movement rates on 19 earthflows averaged 10.2 feet per year (Kelsey, 1987). Since the base of many earthflows is at a stream, the overall movement of an earthflow can generate large amounts of sediment through debris slides into streams. Kelsey (1978) estimated that earthflows contributed 63,600 tons/mi<sup>2</sup> of sediment from 1941 to 1975 in a portion of the Upper Van Duzen watershed. This equates to approximately



SOURCE: Mount (1995)

**Figure 3.6-5.**

Related Impacts Caused by Tree Removal, Soil Exposure and Compaction, and Road Construction Within Logged Areas (Note complex negative Feedback within system)

3.9 feet of surface lowering per century, undoubtedly one of the highest denudation rates on the continent. While this study was located in the Van Duzen watershed, the similarity of parent material and geomorphic features suggests that similar natural denudation rates are occurring elsewhere in the Project Area. The failures typically have a central gully, which collects most of the drainage on the surface of the failure (Harden et al., 1982). One study in the Van Duzen River watershed showed that sediment yield from these axial gullies accounted for as much sediment contribution to adjacent streams as did the toeslopes of the earthflows (Kelsey, 1978). However, in Redwood Creek, to the north and east of the study area, gully surface erosion from earthflows was found to contribute much less sediment relative to the earthflows themselves (Nolan and Janda, 1987).

Earth block glides, another type of deep-seated landslide (for landslide terminology, see Varnes, 1978) tend to be much less obvious, and are usually a part of a larger mobile slope (Kelsey, 1987). While deep-seated failures are not affected by tree root strength, they can be affected by increased residual soil moisture following timber harvest and concentrated road drainage (CDMG, 1982, 1983a, 1983b, 1984a, 1984b, 1984c, 1985a, and 1985b).

While loss of root strength due to timber harvest probably does not affect deep-seated landslides, the increase in soil moisture caused by the decrease in evapotranspiration could cause increased movements (Bedrossian, 1983). Effects are likely to be highly specific to each landslide. Notably, there is a higher risk of impact when deep-seated landslides are adjacent to streams.

### Shallow, Rapid Mass Wasting

The other main form of mass movement is much more rapid. These include the CDMG geomorphic features designated as inner gorges, debris slide

slope/amphitheaters, debris slides, and debris flows. They occur in a matter of hours, minutes, or seconds. Kelsey et al. (1995) summarizes the characteristics of these landslides. They tend to be shallow, generally less than 7 feet in depth and develop on steep slopes, typically greater than 50 percent.

Two natural sources of rapid mass wasting are present in the Northern Coast Ranges of California. The first source is in steep tributary drainages and hillslopes (Harden et al., 1995). These movements are discrete, episodic events that in response to a storm event. Actual movement is primarily translational (versus rotational). The other source of natural failures is from colluvial hollows (Dietrich and Dunne, 1978). Colluvial hollows are more common in competent rock. In the Northern Coast Ranges of California, this includes the unmetamorphosed rocks of the Franciscan Complex. Colluvial hollows develop after a section of weathered bedrock gives way, producing a hollow usually between 30 and 50 feet wide and 5 to 13 feet deep. Over time, the hollow becomes filled with debris from the surrounding hillslopes. Soil forms and the features develop a shallow, concave profile. During an extreme storm event, increased pore water pressure in soil and colluvium causes failure, and the process begins again (Reneau and Dietrich, 1985). Colluvial hollows are an important surface erosional process in competent lithologies. Where present, colluvial hollows may occupy as much as 40 percent of so-called "zero order" drainages or basins. These drainages are depressions found at the head of established drainages and have no surface flow features themselves. Many colluvial hollows are less than five acres in extent.

The mapped features most susceptible to timber harvest activities are debris slideslopes (also called amphitheaters) and inner gorges (CDMG, 1982, 1983a, 1983b, 1984a, 1984b, 1984c, 1985a, and 1985b). Additionally, headwall swales, that are

roughly equivalent to colluvial hollows, are susceptible. These landforms may produce either debris slides or debris avalanches, depending on local conditions. These features are susceptible due to the loss of tree root strength after logging (Zeimer, 1981), and when logging roads are built through them. A recent study showed that inner gorge failures and failures from steep streamside areas accounted for 78 percent of the documented sediment delivering erosion sites in the Lower Eel River area (Pacific Watershed Associates, unpublished report, 1998). However, root strength in harvested redwood forests may be greater because redwoods tend to sprout from the stump which means that some root strength may be retained. Another factor is loss of evapotranspiration due to lack of moisture uptake by trees on a clearcut slope. Water that would have otherwise transpired to the air instead infiltrates through the soil, adding to pore water pressure and potentially leading to landslides (Anderson et al., 1976). This effect diminishes further into the rainy season, because evapotranspiration diminishes to the point where soil becomes saturated anyway (Rothacher, 1971; Harr et al., 1979). An additional source of debris slides and avalanches is road failures, which are discussed below.

### 3.6.2.2 Surface Erosion

The Project Area has some of the highest sediment yields on the continent. The Eel River has a mean annual sediment yield, adjusted to basin area, more than 15 times that of the Mississippi River and 4 times that of the Colorado River, being about 10,000 tons/mi<sup>2</sup> for the period 1957 to 1967 (Brown and Ritter, 1971). There are two sources of this sediment: (1) direct input from mass wasting, such as debris slides (discussed above), and (2) non-breaking surface or overland surface erosion. Natural surface erosion is restricted almost exclusively to the sheet erosion of landslide scars. After timber harvest and road building, however, surface erosion has been

shown to be significant (Marron et al., 1995; Best et al., 1995; Megahan and Kidd, 1972), decreasing site productivity and affecting spawning gravels. Note that surface erosion of hillslopes also is exacerbated by the effective increase in the drainage network that roads and skid trails represent (see Section 3.4). Erosion can be separated into four components: overland flow, rainsplash, rilling, and gullying. Overland flow and rainsplash are commonly grouped together under the general term sheet erosion, indicating erosion that takes place outside a defined channel. Overland flow also is sometimes called sheetwash. It occurs when runoff from rainfall flows in a very shallow, unconfined manner across generally planar slopes. Rainsplash refers to the dislocation of soil particles by the initial impact of raindrops. When a rain drop hits exposed or erodible soil, small soil particles are displaced and move slightly downslope as they settle.

When surface runoff becomes concentrated, the erosive force of water can create small channels or rills. Larger channels may form when rills coalesce, forming gullies. Rilling and gullying are often grouped together as one type of erosion, because both involve concentrated runoff. Sheet erosion generally takes place only on a very localized scale (i.e., several feet to tens of feet). If these processes persist uninhibited for longer distances, existing irregularities in microtopography typically cause rills to form, or runoff may reach small existing drainages. Rills may coalesce to form gullies. Gullying may also be caused by blockage and rerouting of existing drainages. When this occurs, the diverted flow typically will find a new pathway and can erode a new channel in the hillslope.

There are several sources of timber management-related surface erosion; these can be grouped broadly into logging-related hillslope surface erosion and road-related surface erosion.

The use of tractors or skidders during logging activities scrapes away the organic layer and compacts the soils on skid trails, that create avenues for overland flow and can lead to hillslope surface erosion. In addition, cable yarding (when logs are allowed to drag across the surface) also disturbs the surface layer, exposing the soil to surface erosion. Alteration of the surface drainage of a hillslope by logging can indirectly exacerbate erosion created from soil disturbance alone. The potential for surface erosion depends on the extent of surface disturbance.

The second group of surface erosion processes includes road building, which removes the surface layer and exposes soil in the road tread, fillslope, and the cutslope. Maintenance and use of roads (Reid et al., 1981) also has a major effect on road surface erosion. These effects are discussed in Section 3.6.2.3, Roads.

Surface erosion has two attendant effects: it can reduce soil productivity by removing the organic layer (see Section 3.6.2.4): and it can deliver to streams fine sediment, which affects water quality and fish habitat. Delivery to streams can be affected by the site conditions where erosion occurs, and between the eroding area and the stream. Vegetation and debris can effectively prevent fine sediment from sheet erosion from reaching a stream. Stream buffers or RMZs can function in this way, provided they are wide enough, are relatively intact, and continuous (see Section 3.8). An RMZ may need to be 300 feet to filter out clay-size particles (4 microns or less; Wilson, 1967); much of the literature, however, recommends a width of about 100 feet to prevent sediment from reaching streams. Buffers cannot filter out fine sediment in channelized flow, such as in roadside ditches.

#### Hillslope Erosion

Marron et al. (1995) directly measured surface erosion rates on hillslopes, not counting the surface erosion from rills and

gullies. They found that surface erosion varied by parent material and by land use. Surface erosion on logged sandstone slopes was small relative to the estimated basin-wide average of Redwood Creek. Surface erosion on cable-yarded schist slopes, however, was one-half of the basin-wide average. On tractor-yarded schist slopes, surface erosion was twice that of the basin-wide average. This suggests that in spite of the naturally high sediment yield in these basins, tractor logging can have a significant effect on sediment yield, particularly where a watershed is underlain predominantly by sheared, incompetent rock. Post-harvest treatment of skid trails (e.g., waterbarring) and RMZs, however, reduce deliverability of the sediment. The study by Marron et al. (1995) examined the effects of logging that took place mostly in the 1970s; FPRs have changed significantly with regard to tractor logging and road building since then. However, because the study excluded gullying and rilling (which are affected more by tractor and road building), the results are pertinent to current forest practices.

Gully and rill erosion may also be a significant source of logging-related sediment. Weaver et al. (1995) found that low-order drainages were commonly diverted or blocked by roads, plugged culverts, and tractor/skidder trails. Skidder logging disrupted 80 to 85 percent of the surface in their study area. Stream diversions were the cause of most of the gullies observed, in this instance in the Redwood Creek drainage. They also found that thick soils on incompetent rock produced the largest amount of sediment. In addition, gullies greater than 10 square feet in cross section accounted for 80 percent of the sediment yield from gullies. All of the study sites in Weaver et al. (1995) had a mean slope of less than 50 percent. Kelsey (1980) found that 75 percent of the sediment production in the Van Duzen River watershed was

related to gully erosion, although he did not distinguish between natural- and management-induced erosion. Note that several changes in FPRs since the time of Weaver's study (1970s) diminish the relationships between gully erosion and tractor logging relative to current practices. These include the requirement of removing stream crossings of skid trails upon completion of logging operations, although the implementation of some of the FPRs may not be adequate (CDF, 1995).

Kelsey (1980) found that 25 percent of the total hillslope sediment yield from the Van Duzen River watershed came from just 4.1 percent of the watershed. This suggests that broad categorization and ranking of surface erosion hazard on a watershed scale is only the first step in evaluating site-specific surface erosion hazards, and may not in itself adequately characterize sediment inputs. High sediment loads can occur from disturbance of one sensitive area.

In the same study, it was found that during the 1955 and 1964 storms, four times as much sediment was produced from logged areas as from unlogged areas. Most of this sediment was related to road construction, not hillslopes. Notably, the effects of hillslope erosion are dependent on delivery of eroded soil to streams. Delivery is affected by topography and vegetation between the eroding area and the stream. Buffer strips have been shown to be effective in "filtering" out sediment before it reaches the stream, provided that the buffer is wide enough and that vegetation is intact. Johnson and Ryba (1992) surveyed the literature on buffer widths. They found wide variability in the findings of studies dealing with sediment filtration of buffers. However, the recommended buffer widths for sediment clustered around 100 feet. Thus, without knowing site-specific information, the best-available information indicates that most, but perhaps not all, sediment from adjacent disturbed areas is filtered by undisturbed

buffer strips of 100 feet or more. Johnson and Ryba (1992) point out that effectiveness of a buffer for sediment filtration is greatly diminished if flow becomes channelized within the buffer. Because of the concerns indicated above, under FPRs, THPs must address sensitive areas on a site-specific basis.

### 3.6.2.3 Roads

Forest roads have evolved from crude skid trails to highly engineered transportation corridors. A forest road is typically dirt or gravel and has a surface (or "tread") width of 10 to 15 feet. Main haul roads and roads used for winter hauling are generally gravel surfaced. When built on a hillside, the road right-of-way will include significant widths where the hillslope has been removed (cutslope) and where excavated material has been placed on the hillslope below (fillslope). The total width of the road, including cutslope and fillslope, may be up to 100 feet, depending on construction and slope. Typical widths, however, are approximately 40 to 60 feet horizontally. While roads can have a significant effect on slope stability and sediment production, these potential effects can be minimized by proper road location, construction practices, and drainage control. Weaver and Hagans (1994) present details on proper practices.

Roads are considered the main cause of accelerated surface erosion in forests across the western United States (Harr and Nichols, 1993). Processes initiated or affected by roads include landslides, road surface erosion, secondary surface erosion (landslide scars exposed to rainsplash), and gully erosion. In many locations, poorly designed roads have been shown to have a larger effect on sedimentation than hillslope landslides or surface erosion (Kelsey 1980; Best et al., 1995; Wu and Swanston, 1980; Swanson et al., 1987; Ziemer et al., 1996). In the Redwood Creek watershed, stream diversions at roads and skid trails were the leading causes of

hillslope surface erosion (Weaver et al., 1995). These roads were constructed prior to current FPR requirements. McGurk et al. (1996) compiled ratios of sediment production from logging to that of roads, which ranged between 0.005 and 0.11, indicating the dominance of road-related sediment.

Road prism failure can be common in forested watersheds. Failure of the hillslope is usually a result of increased water content or disruption of the natural drainage. When failure occurs, portions of the hillslope underneath the fill material may be removed, as well as the fill itself. Increased water content from poorly designed roads may also concentrate water that can destabilize road fill, existing mass wasting features, or a previously stable hillside.

Sometimes the road cut will fail; this is primarily in response to removing downslope support. When the road cut fails, it usually deposits on the road. This may block the inside ditch and lead to fluvial surface erosion of the road prism as water in the ditch flows around the failure. Stream crossings fail when culverts are not large enough or become plugged with debris. Water and debris will build up behind the road prism, which may collapse from the force of the water or may erode by water overtopping its surface. Sizing requirements for culverts do not account for debris that commonly comes down channels, particularly on small channels.

Road surface erosion is particularly affected by traffic, and sediment yield increases substantially with increases in traffic (Reid and Dunne, 1984). Other important factors that affect road surface erosion include condition of the road surface, timing of when the roads are used in relation to rainfall, road prism moisture content, location of road relative to watercourses, construction methods (e.g., outsloping versus insloping), and steepness on which the road is located. In addition, it

can be reasoned that each piece of a road is heavily used at some point, usually during the timber harvest for which it is built.

Sediment from road surfaces is generated primarily when roads are used during the rainy season. The long-term sediment yield is much lower, however. Road density and number of road/stream crossings are a general indicator of the susceptibility of a watershed to road-generated sediment. Table 3.6-3 shows the number of road/stream crossings on PALCO lands by HU for all classes. In the Humboldt Bay WAA, the lowest number of crossings is in the Jacoby Creek HU, with only two; however, PALCO ownership is very limited in this HU. The highest number of crossings is in Elk River HU, at 356. Salmon Creek HU is also low with 58 crossings. Freshwater Creek is also very high, with 385 crossings. These numbers reflect that Freshwater Creek and Elk River have the highest stream densities in the Project Area.

In general, road maintenance (e.g., clearing plugged culverts), surfacing roads with rock, and road design (properly sized culverts, full bench construction on steep slopes, outsloping of roads and eliminating inside ditches, and rolling dips on either side of a stream crossing) significantly reduce the potential for sediment delivery from roads.

#### 3.6.2.4 Soil Productivity

There are several ways that a soil's ability to grow plants can decrease. First, soils can be removed from production when a road is built or when an impervious surface is

**Table 3.6-3. Road/Stream Crossings on PALCO Lands by Watershed**

<b>HU</b>	<b>Road/Stream Crossings</b>	<b>Number/mi<sup>2</sup></b>
Bear River	212	8.2
Eel Delta	298	17.7
Elk River	356	13.3
Freshwater Creek	385	16.0
Giants Avenue	42	12.0
Jacoby Creek	2	3.4
Larabee Creek	333	14.2
Lawrence Creek	302	12.7
Lower Eel	696	12.4
Middle Yager	59	15.7
North Fork Mattole River	26	3.1
North Yager	46	13.9
Lower Yager	274	12.2
Salmon Creek	58	10.0
Sequoia	217	12.0
Upper NF Mattole River	78	5.7
Van Duzen WAA	344	8.8
<b>Grand Total</b>	<b>3,728</b>	<b>Average 11.4</b>

Source: Foster Wheeler Environmental Corporation

placed on soil. In addition, soil erosion can decrease productivity. The surface layer of soil can be stripped due to loss of vegetative cover or scraping by equipment and subsequent exposure to rainfall (Geppert et al., 1984). This occurs typically when skidders (tractors) are used for logging. Surface erosion of 1 inch of soil in the Plumas National Forest was shown to decrease site productivity by 10 percent (USFS, 1988). The loss of pore space in the soil can affect the ability of seeds to germinate and of plants to re-establish. This effect occurs due to compaction caused by heavy equipment or by skidding logs across the soil surface.

Skidder or tractor logging has by far the greatest effect on soil compaction (Froehlich, 1973). The number of passes a machine makes over a soil is a major factor in causing compaction (Froehlich et al., 1980). The greatest increases in soil bulk

density occur in the first few passes. Therefore, dispersed skidding operations can cause more compaction over a HU than concentrated skidding operations. If the skid trails are minimized, the area compacted can be greatly reduced (Atzet et al., 1989).

Reduction in tree growth is the most prominent effect related to soil compaction; however, this effect has yet to be measured through an entire rotation. So far, research results have been mixed, and much depends upon site conditions; the general trend cited in the literature is a decrease in tree growth on skid trails (Miller et al., 1989). Froehlich (1979) reported a 14 percent reduction in growth of a 17-year-old stand of ponderosa pine on skid trails. Wert and Thomas (1979) measured a 12 percent reduction in Douglas-fir growth on compacted soils. Planted seedlings may do relatively well on

skid trails (Miller et al., 1989), although naturally seeded stands may have only a 20 percent stocking level on skid trails (Steinbrenner and Gessel, 1955). Decreased timber volumes (approximately 10 percent) have been observed in mid-rotation stands (Scott et al., 1979; Wert and Thomas, 1979).

Recovery from soil compaction is slow and can result in reduced timber yields (Hatchell et al., 1970). Soil compaction may result in cumulative effects if harvest rotation is less than about 60 years. For example, Wert and Thomas (1979) measured high bulk densities in skid trails 31 years after use. Natural processes that decrease soil bulk density, such as freeze-thaw cycles, wetting and drying, and animal burrowing, cannot reverse the effects of compaction except over long periods of time. In the Project Area, freezing and thawing may not occur except on a limited number of high elevation areas, and only for short periods in the winter. As rotation periods decrease, and if soil compaction is severe, compaction could be compounded from harvest-to-harvest (Wert and Thomas, 1979). Furthermore, in areas where repeated entries are made, as in a WLPZ, compaction is likely to worsen over time.

Another mechanism that decreases soil productivity is alteration of chemical properties of soil. The most important group of chemical inputs to the soil is nutrients. Presence or absence of nutrients can determine the long-term productivity of the soil. Nutrients are governed by input and output, resulting in nutrient cycling (Stone, 1975). If timber harvest over several rotations decreases the biomass input of nutrients to soil, a deficiency results. If whole-tree harvest takes place (where the stem, branches, and needles are removed), nutrient loss rates increase two to five times the background loss rates (Stone et al., 1979; Alban, 1977). Even if whole trees are not removed from HUs, or if whole trees are moved to a single

site for bucking, the effects on average nutrient levels may be similar to whole-tree harvest (Ulrich, 1981; Stone, 1975). The site index of an area may decrease over time under this type of management. Furthermore, lichen on old-growth Douglas-fir can contribute significant amounts of nitrogen, as can decaying logs (Denison, 1979). These nitrogen fixers are suppressed or absent from managed forests (Forest and Rangeland Resources Assessment Program [FRRAP], 1988). Alternately, if rotation cycle is decreased, soil nutrient cycling can increase (Geppert et al., 1984). Cutting young-growth forests temporarily disrupts the nutrient cycle, but these forests accumulate and return nutrients faster than old-growth forests. The rotation length at which the losses from timber removal are offset by faster nutrient cycling is unknown.

Timber harvest can also change the nitrogen balance by increasing ammonification and nitrification. These effects occur through increases in summer temperature, in soil moisture, and labile organic matter input (Frazer et al., 1990). Additionally, the use of herbicides may affect nitrogen balance by killing nitrogen-fixing herbaceous plants such as legumes. This potential effect has not received much evaluation.

Timber harvest may also change the soil ecosystem. Soil microbes use carbon from fallen trees and branches. Thus, if timber harvest is intensive (e.g., whole-tree harvest and/or short rotations), cumulative effects on soil biological properties may occur (Geppert et al., 1984).

Declines in soil fertility may have long-term effects on forest ecosystems. Site productivity changes may lower the capacity of a site to produce forage or timber (Switzer et al., 1979; Froehlich, 1973). Declines may not be obvious for decades. In California, normal stem harvest of trees, on most sites, with minimal soil surface erosion, causes

nutrient losses at a rate almost equal to nutrient input. However, excessive soil surface erosion, short-term harvest rotation, or harvest in high-elevation sites may increase nutrient losses above the input, decreasing soil fertility (FRRAP, 1988).

Potential loss of timber productivity due to soil effects can be more than offset by management practices that increase growth rates such as control of stocking density and competing vegetation and by planting of improved (faster growing) seedlings.

#### 3.6.2.5 Fire Impact Mechanisms

Burning is commonly employed on the private timberlands of northern California for site preparation, to improve planting access, seedbed conditions, and to reduce competing vegetation. It may also be used to reduce the risk of wildfire by burning logging slash in a controlled fashion. Broadcast burning without redistributing logging slash created during felling and bucking of trees is the most common method of burning in the region and is PALCO's preferred method of site preparation. In addition, large, hot fires that destroy all trees (i.e., stand-replacing fires) happen with long return intervals of more than 100 years. If these occurred, the effects on slope stability from tree root decay would be similar to what occurs after clearcutting. Broad burning, however, would minimize any such fires or related slope-stability effects.

Burning of the vegetative cover can affect the hydrologic response of a watershed, soil productivity, and sedimentation by physical and chemical changes to the soil. These effects are not uniformly distributed throughout a landscape, but are influenced by the site-specific conditions and where logging is taking place. Site conditions that are relevant to burning effects include the kind, amount, moisture content, and distribution of slash and residual

vegetation; topographic features such as slope, aspect, and drainage pattern; and the temperature, humidity, and wind at the time of burning.

Physical changes in the soils depend largely on the temperature of the soil during burning. An intense burn can destroy the litter material on the soil surface and the organic matter in the upper mineral layer of the soil. The loss of organic matter changes such physical properties of the soil such as increasing bulk density, diminishing aggregate stability, and decreasing micro- and macro-pore space. In addition, a fire can produce a water-repellent layer in all soil types that reduces surface infiltration and increases runoff (University of California, 1979). However, most controlled broadcast burns do not get hot enough to significantly affect the soil's water-absorbing capacity (DeByle, 1973). A study of soils in the western Cascade Mountains of Oregon and Washington found no effects of broadcast burning on soil physical properties (i.e., water repellency) 25 years after burning (Kraemer and Hermann, 1979).

Burning of the organic matter in the soil can result in decreased soil productivity. Nitrogen is the nutrient most significantly affected by fire (University of California, 1979). In hot fires, as much as 60 percent of the nitrogen in burned materials can be released through volatilization, in which nitrogen is released to the air, not the soil. In the southern Oregon Cascades, Powers (1980) found that 10 years after logging and slash burning, plant available nitrogen levels in the burned areas were one-third lower than in adjacent logged, unburned areas and adjacent unlogged old-growth forest. In addition, nutrients are more easily lost by leaching after a fire. If a fire is extremely hot, for example, greater than 932°F, 100 percent of the nitrogen from burned materials may be lost. Logging, combined with burning of the forest understory, can lead to nitrogen depletion, because the nitrogen inputs from living

plants are eliminated. In addition to nitrogen, pH, cation exchange capacity (CEC), and organic matter can be affected by fire. pH is increased by fire because ions contained in plants and forest litter are released. CEC is decreased because organic matter is lost and organic matter contains cation exchange sites. Fire often destroys microorganisms in the soil; mycorrhizae are of particular concern because many trees (commercial and non-commercial species) depend on them (Borchers and Perry, 1990). Some studies have linked declines in mycorrhizae with reduced tree regeneration, but this is probably limited to areas in which it is naturally difficult for trees to grow (Borchers and Perry, 1990).

It is fairly well established, however, that low-intensity fires do not significantly deplete soil nutrients (Geppert et al., 1984; Beschta, 1990; McNabb and Cromack Jr., 1990). Recovery from changes in soil chemistry is relatively rapid. Jurgenson et al. (1981) found that increased levels of ammonium and nitrification lasted only one year and no long-term depletion of soil nitrogen resulted from broadcast burning. Additionally, with second-growth harvest, the intensity of broadcast burning is likely to be less than a harvested old-growth stand, because there is generally less slash to burn.

Fire can also lead to sedimentation. Burning of the organic layer of a forest soil can expose the underlying mineral soil to erosion. If a water-repellent layer develops, runoff across a slope would increase, accelerating hillslope erosion. In addition, stream buffers (RMZs) may lose their sediment filtration capacity if the ground cover burns. The effect of fire on a stream buffer is influenced by the type of buffer. In a buffer that is composed of evenly aged trees, there is less fuel between the understory and the overstory, and fires that originate in adjacent clearcuts would likely spread as ground fires. Under these conditions, sediment

filtering of a buffer strip would be lost until revegetation occurs in a few years. Loss of sediment filtering would occur when it is needed most, since the adjacent clearcut would be unvegetated. When a forest contains multiple canopy levels, a continuum of fire fuels is created. Under this scenario, a ground fire could spread through the different layers of forest. If the buffer burns, the functions of sediment filtration, LWD recruitment, shade, and streambank stability would be lost (see Section 3.7, Wetlands and Riparian Lands).

All of the above effects may increase or decrease depending on harvest rotation length (or frequency of other disturbances). The rate of nutrient uptake is greatest at about the point of crown closure, and short rotations place a greater drain on nutrients than long rotations (Powers et al., 1990). Shorter rotations also short-cut the nutrient input that occurs in mature stands (Sollins et al., 1980). However, in general, rotations greater than 60 to 80 years should not export nutrients faster than they accumulate (Powers et al., 1990).

#### 3.6.2.6 Grazing Impact Mechanisms

Cattle and sheep grazing has occurred on certain parts of the Project Area since the early 1900s. In the 1920s, PALCO was actively converting forested land into pastures. Approximately 1,000 head of cattle and sheep were grazed on 15,000 to 25,000 acres of logged and open land. Prairie conversion diminished in the 1940s and PALCO began purchasing natural prairies and existing ranches. Currently, about 5,700 acres is leased to private cattle operations and about 600 head of cattle graze this area. This number has decreased from a historical use of 2,000 to 3,000 head of livestock. A general estimate of the quality of the PALCO's leased lands was produced from limited site-specific information and consultation with range land specialists. It was estimated that approximately 6 to 10 acres of pasture land is needed per animal unit (Personal

communication, G. Markegard, 1998) across all of PALCO's leased properties. As stated earlier, this estimate may vary depending upon site-specific conditions. Currently, there are 1.3 to 18 acres per animal unit month (AUM) across PALCO's lands (average of 10 acres per AUM). An AUM is defined as the amount of forage and/or browse required to feed a cow and her calf for a month. There are fifteen different areas that are leased for grazing. Most of these areas contain exclusion measures or have inherent site features that limit livestock access to streams.

Many factors including vegetation structure and composition, topography, and water availability can influence the quality of range land for grazing. Additionally, behavioral characteristics of cattle must be taken into account when evaluating range land. Cattle are creatures of habit, using the same territories repeatedly, often leaving as much as 65 percent of available pasture untouched. Livestock develop preferences for certain plant species and learn to become highly selective during grazing. They choose green leaves over stems and old forage. If given the opportunity they regrazed individual plants several times during the growing season, eating the succulent regrowth. These behavioral grazing preferences can weaken the preferred forage plants. Additionally, livestock are reluctant to use steeper slopes and tend to graze at lower elevations near water. Grazing is also limited by the horizontal distance from water, and livestock rarely graze farther than four miles from it. They readily seek shade during hot summer periods, resulting in high usage of forested and riparian areas.

Grazing of livestock can cause adverse effects to soils, streambanks, and water quality (Platts, 1991). Water quality effects are discussed in Section 3.4. The effects of grazing on soils, streambanks, and watershed parameters will be discussed here. Grazing modifies evapotranspiration and infiltration, which can affect the total

yield of water from a watershed and the timing of runoff to streams. Vegetation loss in upland and riparian areas results in decreased interception and transpiration losses, increasing the amount of water available for surface runoff and erosion (Heady and Child, 1994). Another result of increased runoff is a more rapid hydrologic response of streams to rainfall. Moist soils tend to be affected more heavily by grazing than dry soils, although extremely wet soils may recover more readily following trampling by livestock (Clayton and Kennedy, 1985). Soil compaction increases the bulk density of the top 5 to 15 centimeters of soil as pore space is reduced. The loss of pore space results in the loss of soil infiltration capacity, thereby increasing surface runoff and the potential for erosion.

Grazing may also alter surface soils indirectly by removing ground cover and mulch, which affects the soil response to rainfall. Kinetic energy released by falling raindrops detaches soil particles, which then may settle in the interstices of the disturbed ground (soils) creating a relatively impervious surface (Spence et al., 1996). Rills and gullies often form in areas denuded by livestock trails or grazing. Vegetation loss and exposure of soil by grazing increases overland sediment transport. Mass wasting of sediment occurs along streambanks where livestock trampling has occurred. When the stream vegetation is denuded, undercutting and sloughing occurs, and sediment input increases (Fleischner, 1994).

Livestock grazing can severely affect riparian zone vegetation when livestock congregate in these areas. The grazing animals are attracted by water, shade, cooler temperatures, and abundance of high-quality food that usually remains greener than in upland areas. Grazing in riparian areas can reduce streambank stability and lead to channel incision or "downcutting" during periods of high runoff. In naturally functioning systems, streambank vegetation stabilizes the banks

and slows the flow of water, thereby decreasing the erosive power of the flowing water. The slower flows allow the water to spread out over the floodplain and recharge subsurface aquifers (Elmore, 1992). In addition, riparian vegetation promotes sediment deposition and bank building, and increases the capacity of floodplains to store water that is then slowly released as baseflow during drier seasons (Elmore and Beschta, 1987). When the vegetation is removed, erosive power of the stream increases, the banks are exposed to erosion, and the channel may be downcut. This effectively separates the channel from the floodplain, allowing floodwater to be quickly routed out of the system, leading to a lowering of the water table and the loss of riparian function (Elmore, 1992).

Riparian vegetation also shades streams and regulates stream temperature. The removal of riparian vegetation can result in increased solar radiation and thus increased summer temperatures. Alteration of riparian vegetation may result from changes in channel morphology. Grazed streams tend to be wider and shallower than in ungrazed systems, exposing a larger surface area to incoming solar radiation and therefore increased temperatures (Platts, 1991). Reducing the stream depth may expose the stream bottom to direct solar radiation, which may allow greater heating of the substrate and subsequent conductive transfer to water (Spence et al., 1996).

Another impact of grazing is the loss of aquatic habitat. Loss of root structure promotes greater instability of streambanks, which reduces the formation of undercut banks that provide important cover for salmonids (Henjum et al., 1994). The increased deposition of fine sediments from bank sloughing may clog streambed substrate interstices, reducing invertebrate production and the quality of spawning gravels. The lack of structural complexity allows greater scouring of streambeds during high-flow events, which can reduce

gravels available for spawning and facilitate channel downcutting (Platts, 1991; Elmore, 1992).

### 3.6.3 Environmental Effects of Alternatives

The alternatives contain numerous and varying timber management and road building practices. Under all alternatives for any issue not specifically addressed, the default timber management in the upslope areas (i.e., non-riparian zone) would be governed by application of the FPRs. These are an extensive set of regulations governing the management of timber on private lands.

Since current FPRs and THPs are considerably more protective than previous rules, the results of past studies on timber harvest effects may overestimate effects of current forest practices on surface erosion and mass wasting. In other words, if a watershed was logged exclusively by practices approved under the 1997 FPRs, the resulting effects on erosion and mass wasting would be different than, and considerably less than, effects in an identical watershed harvested over several previous decades and under various versions of the FPRs. It may never be possible to identify effects of specific versions of the FPRs because nearly all watersheds have been harvested under multiple sets of regulations. In addition, the legacy of past timber harvest practices may continue to contribute to sedimentation of streams. Furthermore, streams (particularly larger streams) are continuing to recover from the impact of extreme events, such as the 1964 flood. In predicting effects of future timber harvest operations, the improved forest practices should be taken into account, along with the nature of a landscape recovering from past disturbances.

The effects of each alternative on geomorphic processes are summarized in Table 3.6-4.

### 3.6.3.1 Timber Harvest-related Mass Wasting

Various types of landslides (mass wasting) occur naturally in the Project Area. Landslides that are triggered by timber harvest are generally those with failure planes shallow enough to be affected by loss of root strength. As discussed in Section 3.6.2, deep-seated landslides may be affected by increased soil moisture from timber harvest, although this causal relationship is difficult to demonstrate. The main variable for assessing the effects of the alternatives is the amount and type of protection given to unstable areas for loss of root strength. It is important to note that hillslope strength diminishes several years after timber harvest and typically recovers completely in about 20 years (Chamberlin, 1982). None of the alternatives provides specific protection for deep-seated landslides, although some incidental protection is gained by other protection measures and by administrative processes included in the alternatives that provide for review of unstable areas at a later date.

#### Threshold of Significance

The interrelationship of management activities, environmental components or systems, and related thresholds of significance, are discussed in Section 3.1 and illustrated in Figure 3.1-1. Section 3.1 describes the interrelationship of effects among the environmental components and the related thresholds of significance for Sections 3.4, Watersheds, Hydrology, and Floodplains; 3.6, Soils and Geomorphology; 3.7, Wetlands and Riparian Lands; and 3.8, Fish and Aquatic Habitat.

Timber harvest-related mass wasting is dependent on site-specific conditions, especially geology and the distribution and timing of timber harvest. Site-specific predictions of hillslope mass wasting cannot be made at the scale of this analysis. Therefore, the relative risk of

mass wasting occurring above the natural, background rate was assessed. Risk was ranked as low, moderate, or high, and was evaluated based on the potential for occurrence of landslides, the measures proposed to minimize landslides (i.e., both avoidance and specific prescriptions), and the threat of affecting people, property, or aquatic habitat (i.e., deliverability). The best available information from the literature, Coarse Sediment, Fine Sediment, and Soil Productivity along with professional judgement, was used for the evaluation. A high risk is considered to exceed the threshold of significance. A moderate or low risk is considered to be below the threshold of significance.

#### Alternative 1 (No Action/No Project)

The state and federal assumptions for assessing environmental impacts to aquatic resources under the No Action alternative differ due to differences in analysis approach required by CEQA and NEPA. CEQA implementing regulations require that an EIR discuss “the existing conditions, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved” (14 CCR 15126[d][4]). CEQA does not require either a projection into the long-term future that could be deemed to be speculative, nor does it require a quantitative analysis of the No Project alternative for comparison with the other alternatives. Accordingly, the state version of the No Action/No Project alternative analyzed here contemplates only the short term and is based on individual THPs that would be evaluated case by case. The CDF version of No Action/No Project does not attempt to forecast how PALCO’s entire property would look in 50 years (the length of the proposed ITP). Since it is unknown how many THPs there would be, where they would lie geographically, and how they would differ in detail, no quantitative analysis of THPs is presented (see Section 2.5).

**Table 3.6-4.** Effect of Alternatives on Coarse Sediment, Fine Sediment, and Soil Productivity

Geomorphic Process/ Management Activity	Impact Parameter		Soil Productivity
	Coarse Sediment	Fine Sediment	
<b>Alternative 1</b>			
Hillslope erosion	N/A	-	-
Road surface erosion	0	-	N/A
Road-related mass wasting	-	-	0
Timber harvest-related mass wasting	0	0	0
Effects of burning	0	0	0
Effects of grazing	0	0	0
Timber harvest methods	N/A	-	0
Overall effect	-	-	0
<b>Alternative 2</b>			
Hillslope erosion	N/A	+	+
Road surface erosion	0	-	0
Road-related mass wasting	+	+	0
Timber harvest-related mass wasting	+	+	0
Effects of burning	0	0	+
Effects of grazing	0	0	0
Timber harvest methods	N/A	0	0
Overall effect	+	+	0
<b>Alternative 3</b>			
Hillslope erosion	N/A	+	0
Road surface erosion	0	+	N/A
Road-related mass wasting	+	+	0
Timber harvest-related mass wasting	+	+	0
Effects of burning	0	+	0
Effects of grazing	0	0	0
Timber harvest methods	N/A	+	-
Overall effect	+	++	0
<b>Alternative 4</b>			
Hillslope erosion	N/A	0	0
Road surface erosion	0	-	N/A
Road-related mass wasting	+	+	0
Timber harvest-related mass wasting	+	+	0
Effects of burning	+	+	0
Effects of grazing	0	0	0
Timber harvest methods	N/A	+	0
Overall effect	++	++	0
0 = negligible trends			
- = negative trend away from background			
-- = rapid negative trend away from background			
+ = positive trend toward background			
++ = rapid positive trend toward background			
N/A = not applicable			
Background = mature forest in a managed landscape			
Source: Foster Wheeler Environmental Corporation			

The likely No Action/No Project alternative would consist of PALCO operating in a manner similar to current THP practices and subject to existing CDF authority. In reviewing individual THPs, CDF is required to comply with the FPA, FPRs, and CEQA through its certified functional equivalent program (see Section 1.6). The specific criteria for evaluating THPs contained in the FPRs are combined with the case-by-case evaluation of each THP for significant effects on the environment followed by consideration of alternatives and mitigation measures to substantially lessen those effects. Under CEQA and the FPRs, CDF must not approve a project including a THP as proposed if it would cause a significant effect on the environment and there is a feasible alternative or feasible mitigation measure available to avoid or mitigate the effect. An adverse effect on a listed threatened or endangered species would be a significant effect under CEQA.

In addition, the present FPRs provide that the Director of CDF shall disapprove a timber harvesting plan as not conforming to the rules if, among other things, the plan would result in either a taking or a finding of jeopardy of wildlife species listed as rare, threatened, or endangered by the CDFG or a federal fish or wildlife agency or would cause significant, long-term damage to listed species. To make a determination as to the effect of a THP on listed fish or wildlife species, CDF routinely consults with state and notifies federal fish and wildlife agencies. These processes and independent internal review by CDF biologists can result in a THP containing additional site-specific mitigation measures similar to the ones described in the Proposed Action/Proposed Project. CDF believes that its existing process using the FPRs and the CEQA THP-by-THP review and mitigation are sufficient to avoid take of listed species.

The mitigation by which an individual THP is determined to comply with FPRs, the

FESA and CESA, and other federal and state laws is determined first by compliance with specific standards in the FPRs and then by development of site-specific mitigation measures in response to significant effects identified in the CEQA functional equivalent environmental analysis of the individual THP. A wide variety of mitigation measures tailored to local conditions is applied with the purpose of avoiding significant environmental effects and take of listed species. These include, but are not limited to, consideration of slope stability, erosion hazard, road and skid trail location, WLPZ width, BMPs on hillslopes and within WLPZs, and wildlife and fish habitat. Consequently, most significant effects of individual THPs can be expected to be mitigated to a level of less than significant through implementation of the No Action/No Project alternative. In some cases, CDF may determine that it is not feasible to mitigate a significant effect of a THP to a level of less than significant. In such a situation, CDF would need to determine whether specific provisions of the FPRs such as not allowing take of a listed threatened or endangered species would prohibit CDF from approving the THP. If approval is not specifically prohibited, CDF would need to weigh a variety of potentially competing public policies in deciding whether to approve the THP. A THP with a significant remaining effect could be approved with a statement of overriding considerations, but such an approval would be expected to be rare.

As noted in Section 2.5, under NEPA, the degree of analysis devoted to each alternative in the EIS will be substantially similar to that devoted to the Proposed Action/Proposed Project. The federal agencies recognize that a wide variety of potential strategies could be applied that could represent a No Action/No Project scenario and that they would involve consideration of the same mitigation measures as described above. For the

purposes of analysis under NEPA, however, these additional mitigation measures are represented as RMZs, rather than management options developed for site-specific conditions. Consequently, the analysis of the No Action/No Project alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZ width are considered qualitatively because adequate buffer widths could vary as a result of varying conditions on PALCO lands.

Under this alternative, existing FPRs related to mass wasting would be in effect and would be implemented under each THP submitted for review. Unstable areas are required to be identified in THPs and mitigated or avoided. If a known landslide or potential landslide is present in the THP area, or concerns are expressed by the public, a review by CDMG may be conducted to determine the feasibility and/or mitigation for logging. The FPRs generally limit or avoid road construction across these areas, or require special plans. However, the geomorphic feature maps used in this analysis are intended for landscape-level planning, not project-specific planning. Therefore, unless additional site-specific mapping is conducted, some potential for increased mass wasting would exist under this alternative, due to timber harvest on previously unmapped unstable areas. A report by the CDMG contains general prescriptions for preventing increased landslide activity (CDMG, 1983). However, site-specific mitigation measures would be necessary to reduce landslide potential. Recent reviews of several planning watersheds within the Lower Eel HU and the Humboldt Bay WAA indicate significant cumulative effects of timber harvest on streams under existing FPRs, with mass wasting being the main cause (CDF, unpublished report, 1998).

Those watersheds with higher proportions of landslide-related features would be more susceptible to timber harvest-related landslides. These include the Bear River, Lower Eel, Mattole, and Van Duzen HUs. Recent aerial photograph and ground surveys indicate that in the Yager and Van Duzen WAAs and the Lower Eel HU landslides emanating from clearcut and partial cut hillslopes are at least as numerous as road-related landslides, and that landslides originating from logged hillslopes approximately double the number of landslide sites (Pacific Watershed Associates, unpublished report, 1998).

Under the alternatives, some incidental protection against shallow rapid landsliding would be given through the RMZs. Because RMZs would be relatively wide, they would include some of the inner gorges and debris slides designated in the CDMG maps. Also, they could decrease the runoff of shallow-rapid failures higher upslope, preventing some or most of the sediment from being delivered. Landslides originating in the headwalls of first-order streams would generally not be explicitly protected, unless they are recognized as unstable. Therefore, a moderate risk of mass wasting would be present under this alternative with respect to people and property.

#### *INDIRECT EFFECTS ON CHANNEL MORPHOLOGY*

If timber harvest-related mass wasting occurs, positive feedback within the stream systems could result. Increased coarse sediment supply to streams could occur; this sediment would be stored in stream channels downstream from the mass wasting sites. This storage, or aggradation, would increase the stream's width-to-depth ratio, a direct impact on aquatic organisms. In addition, streams could respond to the shallower channels by eroding laterally. This could decrease streambank stability and cause small streamside landslides. In inner gorges,

larger failures (debris slides) involving the streambank and the hillslope could occur. Streambank failures and debris slides could cause additional sediment inputs that would add to channel widening, lateral erosion, and more streambank failure downstream. This positive feedback would cause adverse effects to persist and propagate in the downstream direction. Based on the risk of mass wasting associated with this alternative, the risk of effects on channel morphology is also moderate (Section 3.8).

#### Alternative 2 (Proposed Action/Proposed Project)

This alternative provides more specific protection against timber harvest-related shallow rapid landslides than Alternative 1. Protection against mass wasting related to timber harvest would be accomplished through several steps. In the short term, PALCO would conduct watershed analyses and develop specific prescriptions on its entire property within 5 years. Timber harvesting during this period would use a geomorphic sensitivity rating based on GIS data layers. This rating system uses bedrock type, geomorphic features, slope, and soil type (see Appendix 3 of the HCP/SYP; PALCO, 1998). Arbitrary numbers were assigned to each category of each parameter. The GIS was used to then assign aggregate numbers to discrete land units. The numeric total of the rankings was then assigned a qualitative ranking from low to extreme sensitivity. This analysis was intended to generate landscape-level assessment for planning purposes. Features smaller than 6 acres, the resolution of the GIS layers, would be missed. If these features make a significant contribution to sediment, then this ranking if used as a prescription tool, would create a substantial risk of timber harvest-related mass wasting. However, individual THPs would still undergo the normal development and review processes, which also considers small mass wasting features.

Under the hillslope management default prescriptions (Appendix E), landslide hazard zone areas with ratings of extreme, very high, and high (including inner gorges) would be no-harvest zones and would have no new roads built. These restrictions would apply unless a professional geologist, a forester, and at least one agency biologist determine if alternative prescriptions are appropriate and are not likely to increase the risk of hillslope failure. Additional details are included in Appendix E.

Under watershed analysis, mass wasting hazards would be identified in the "mass wasting module," as used by the WDNR and modified for use by PALCO. The WDNR methodology contains an analysis step and a prescription step. The mass wasting module calls for mapping of existing landslides using several series of aerial photographs, followed by field verification. Ultimately, a hazard potential map is generated, extrapolating information from the mapped landslides to the entire watershed. Under step two, measures (prescriptions) are developed to mitigate effects of logging unstable areas. The prescriptions range from no harvest to heavy selective harvest, or they may defer prescriptions to a site-specific analysis by a geologist.

Other provisions of the watershed analysis process include the following:

- Post-watershed-analysis RMZ prescriptions for both Class I and II watercourses shall be no less than 30-foot, no-cut (slope measurement) and no more than 170-foot (horizontal measurement) buffer zones on each side of the watercourse.
- With respect to the minimum 30-foot, no-cut (slope measurement) buffer zone on Class II watercourses, NMFS or FWS may adjust the buffer to a minimum 10-foot, no-cut buffer zone if it is determined that it will benefit aquatic habitat or species.

The WDNR watershed analysis process has been criticized (Collins and Pess, 1997) for not following up assessment procedures with appropriate prescriptions. While the mass wasting module identifies areas at future risk of landslides, the prescription phase often defers final mitigation to a site-specific analysis at the time of timber harvest. Due to the lack of concrete guidelines for prescriptions as they relate to the individual resource assessments, there is a degree of uncertainty in the level of protection given by watershed analysis prescriptions. Nevertheless, the purpose of watershed analysis is to integrate the existing and potential hazards to public resources (water, fish, and infrastructure), and as such presents a holistic and detailed program for mitigating timber harvest effects on mass wasting. While there may be some uncertainty in the prescription effectiveness compared to more rigid protection measures (see Collins and Pess, 1997), such as wide stream buffers, this method does focus on the overall effects of timber harvest on a watershed, including a synthesis section devoted to integrating the multiple disciplines relevant to aquatic habitat management. As such, watershed analyses and the implementation of the site-specific prescriptions it would develop would be expected to reduce the risk of damaging mass wasting to at least moderate risk. A moderate risk was assigned rather than low due to the uncertainty involved. A high risk was ruled out due to the level of detailed effort, which would identify those areas that are sensitive to mass wasting as well as the stream reaches that are vulnerable to mass wasting inputs.

Under this alternative, the applied RMZs (see Section 3.7, Wetlands and Riparian Lands, for a detailed discussion) also provide additional avoidance of unstable ground adjacent to streams, such as debris slides and inner gorges. Class I stream RMZs would be 170 feet (slope distance). The first 100 feet would be a no-harvest

band which would conserve root strength. This band would provide substantial protection from mass wasting. In the outer band (OB) (100 to 170 feet), partial harvest can occur (240-square-foot basal area must remain). However, downed wood must remain on slopes greater than 50 percent, and full suspension yarding would be used when feasible. The prescriptions for the OB reduce the ground disturbance in the RMZ, which provides additional protection from timber harvest-related mass wasting. If any area within the RMZ, including the area in the 50 percent slope provision band, falls within the definition of a mass wasting area of concern, then the mass wasting strategy applies.

Along Class II streams, the 30-foot (slope distance) no-harvest buffers along all timber types and slopes would provide moderate protection for root strength. The late seral prescription harvest zone (30 to 100 feet in the Humboldt Bay WAA and 30 to 130 feet outside of the Humboldt Bay WAA) for slopes less than 50 percent would also provide protection from mass wasting. For slopes greater than 50 percent, the late seral prescription would extend beyond the 100 to 130-foot zone and must be applied all the way to the break in slope. For steep slopes, this also provides moderate protection from mass wasting. In addition, if any area within the RMZ, including the 50 percent slope provision band and sediment filtration band, falls within a mass wasting area of concern, then the mass wasting strategy applies.

Timber harvest could occur next to Class III streams, but they are EEZs. Many debris slide/slope amphitheaters are located on Class III streams. However, the headwaters of many Class III streams are commonly headwall swales which would be protected (no-harvest) under the hillslope management prescriptions. Because the resolution of the geomorphic sensitivity maps is low, many unstable areas may be overlooked at the landscape scale. However, the normal THP preparation and

review process would consider mass wasting potential.

During the first 10 years, timber harvest would be focused on the Freshwater, Elk River, Lower Eel, and Lawrence Creek HUs, although all HUs would have some timber harvest (Table 3.4-7). Among these, the highest proportion of landslide-prone terrain is in the Lower Eel HU, although all of the HUs have at least 10 percent landslide-prone terrain. Thus, the risk of timber harvest-related landslides would be greatest in the Lower Eel HU. CDF has identified the Jordan Creek watershed as cumulatively impacted by sediment. In this watershed, CDF will require special prescriptions that prevent sediment effects before individual THPs are approved.

Creation of the Headwaters Reserve would prohibit timber harvest in the upper portions of Salmon Creek and Elk River HUs. Thus, there would be no timber harvest-related mass wasting in these areas.

Because landslides could occur along Class III streams and debris slide slope/amphitheatres there would be a low to moderate risk of coarse and fine sediment delivery to streams under this alternative. This level of potential effect is considered to be less than significant under CEQA with respect to people and property.

Based on public comments and FESA and CESA issuance criteria, the wildlife agencies consider that additional mitigation would be appropriate to reduce the risk of potential adverse effects. These additional mitigation measures would further reduce the impacts as described in the Draft and Final EIS/EIRs. This additional mitigation is summarized in Section 3.4.3.8. Detailed descriptions of the mitigation measures are provided in Appendix P.

## Indirect Effects

The mechanisms for indirect effects would be the same as under Alternative 1. However, the risk of such effects would be lower across the landscape. Indirect effects would occur in watersheds with a high percentage of landslide-prone terrain, where the chances of not identifying unstable areas are higher. This includes the Lower Eel HU, Freshwater Creek, and Lawrence Creek. The indirect effects could occur in response to extreme storm events and/or in highly unstable areas. Based on this risk of mass wasting associated with this alternative, the risk of effects to channel morphology is also low to moderate (Section 3.8).

### Alternative 2a (No Elk River Property)

This alternative would be nearly identical to the proposed HCP; about 9,500 acres would remain with the Elk River Timber Company. Existing FPRs would apply to the timber management on this land. Only the Elk River HU would be affected differently than under the proposed HCP. There would be a moderate to high risk of mass wasting in this area, based on the analysis of the FPRs presented under Alternative 1 above.

### Alternative 3 (Property-wide Selective Harvest)

Under this alternative, root strength on unstable slopes would be diminished to a lesser degree than if clearcut, although quantitative estimates of the actual decrease are not possible. The target tree size distribution would probably be enough to protect for root strength in many places. However, the most unstable areas could lose sufficient root strength to increase risk of landslides. It is not known where and how much land would be at increased risk, although it would be less land in general than under Alternatives 1 and 2.

Incidental protection would be substantial, with approximately two acres in no harvest old-growth areas with an associated half-

mile buffer. RMZs would also contribute significantly to avoiding potentially unstable sites. The amount of no-harvest RMZs would be greater, especially for Class III streams, which would receive minimum 25-foot, no-harvest zones. Additionally, in the watersheds recently identified as having cumulative impacts due to sediment, the required analyses would lead to more-specific protections for shallow landslides. During the course of the HCP, all HUs within the PALCO ownership would be analyzed and sediment budgets would be developed. Although the procedures proposed for mitigation (Weaver and Hagans, 1994) do not contain mitigation for timber harvest-related landslides, the requirement of selective harvest would help prevent many landslides.

This alternative presents a relatively low risk for increased mass wasting due to timber harvest. This level of risk is below the threshold of significance for people and property.

#### Indirect Effects

The mechanisms for indirect effects would be the same as under Alternative 1. However, the risk of such indirect effects would be low under Alternative 3, because the risk of increased coarse sediment supply would be low (Section 3.8).

#### Alternative 4 (63,000-acre No-harvest Public Reserve)

Under this alternative, the effects across most of the PALCO ownership would be the same as those under the proposed HCP. However, much of the Yager Creek WAA, and portions of the Elk River and Salmon Creek HUs would be protected against any potential timber harvest-related landslides, since no timber harvest would be allowed. Within several decades, the rate of mass wasting would approach background, pre-logging levels, based on an estimated root strength recovery within 20 years (Sidle, 1985). Therefore, there would be a low risk

of increased sediment supply in the Reserve, while outside the Reserve risk of sediment influx would be low to moderate. Indirect effects would generally be minimal, although during extreme storm events, large pulses of sediment from mass wasting could reach streams. The effects associated with the HCP/SYP under this alternative are below the threshold of significance for people and property.

#### 3.6.3.2 Road-related Mass Wasting

Logging roads are widely documented as a significant source of sediment (Megahan and Kidd, 1972; Cederholm and Reid, 1987; Chamberlin et al., 1991; Nolan and Janda, 1995; and Bolda and Meyers, 1997). In addition to sediment from road surface erosion, sediment is also generated from mass wasting of the road bed, which can occur anywhere along a road, but is most significant where the roadbed is made of fill and the hillslope is steep. Stream crossings can also fail catastrophically, either from mass wasting, fluvial erosion from culvert failure, or a combination of both (see Section 3.6.2 above). Failure at these sites is important because sediment is delivered directly to streams. The primary means used to evaluate the alternatives are the proposed road treatments that address stream crossings. The total road miles and total stream crossings do not vary significantly among alternatives, although they vary between watersheds. Generally, stream crossings would increase over current conditions for all alternatives. Although the location of the new stream crossings is not known, the increases would be minor except in those HUs where there would be significant increases in road density (see Table 3.6-5).

#### Indirect Effects

The mechanisms for indirect effects would be the same as under Alternative 1. However, the risk of such indirect effects would be low under Alternative 4, and the risk of increased coarse sediment supply would be low (Section 3.8).

## Threshold of Significance

Road-related mass wasting is dependent on road construction and maintenance methods. Site-specific predictions of road-related mass wasting cannot be made at the scale of this analysis. Rather than a quantitative threshold of significance, therefore, the relative risk of road failure was evaluated. Risk was ranked low, moderate, or high and was evaluated based on the potential for occurrence of landslides, the types of maintenance procedures applied, the road location and design features, and the threat of affecting people, property, or aquatic habitat (i.e., deliverability). A high risk is considered to exceed the threshold of significance. A moderate or low risk is considered to be below the threshold of significance.

## Alternative 1 (No Action/No Project)

As noted in Section 2.5 and Section 3.6.3.1, the evaluation of the No Action/No Project differs under CEQA and NEPA. For CEQA the No Action alternative is not projected into the long-term future. In the short term, the conformance with the FPRs, the FESA and CESA, and other federal and state laws is determined on a THP and site-specific basis. A wide variety of mitigation measures tailored to local conditions is applied with the purpose of avoiding significant environmental effects and take of listed species. Consequently, most significant environmental effects of individual THPs can be expected to be mitigated to a level of less than significant through implementation of the No Action/No Project alternative.

As noted in Section 2.5 and Section 3.6.3.1, the NEPA evaluation of the No Action alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZs are considered qualitatively because adequate buffer widths could vary as a result of varying conditions on PALCO lands.

Under this alternative, it is assumed that the same amount of roads would be built as under the SYP, about 400 miles over 50 years. While these new roads would be built to new standards, more restrictive than previous FPRs, the new roads would be a 26 percent increase in total roads. Combined with the existing road network and high road densities, significant effects on mass wasting would be expected. The road density by HU is known for the first 10 years (see Figure 3.6-4). There are no projections at this scale for the remaining 250 miles of road to be built. It can be assumed, however, that those HUs with relatively low road densities would experience an increase in road density to the approximate level of those that have high road densities. Therefore, it is assumed that in most watersheds, road density would eventually surpass what is considered the minimum density at which there are effects on sediment.

Many existing road stream crossings are not designed to accommodate 50-year flows and tend to accumulate organic debris, which plugs culverts and can lead to mass wasting events during high-intensity storms. To date, no formal inventory of road conditions has been conducted; specific sites where these "legacy" roads have the potential to contribute significant sediments at stream crossings and elsewhere cannot be predicted at this time.

While PALCO currently conducts road maintenance and has stormproofed some roads, there would be no explicit stormproofing program in the future under this alternative. Therefore, it is likely that road fill and stream crossing failures could be a significant source of sediment to streams during large storm events. The protection of bank stability through no-harvest RMZs on all streams would substantially decrease the risk of debris flows and subsequent road crossing failures, although some could still occur sporadically. In addition, under Section 1603 of the Fish and Game Code,

**Table 3.6-5.** Linkages Between Geomorphic Processes, Timber Harvest Practices, and Impact Parameters

Geomorphic Process/ Management Activity	Impact Parameter		
	Coarse Sediment	Fine Sediment	Soil Productivity
Hillslope erosion	No	Yes	Yes
Road surface erosion	No	Yes	No
Road-related mass wasting	Yes	Yes	(minor)
Timber harvest-related mass wasting	Yes	Yes	(minor)
Effects of burning	No	Yes	Yes
Effects of grazing	No	Yes	Yes
Timber harvest methods	No	No	Yes

Source: Foster Wheeler Environmental Corporation

individual permits for stream crossing construction could be required, the terms of which would be negotiated on a case-by-case basis. Given the lack of a concerted and consistent effort to prevent stream crossing failures, and relatively high road densities across PALCO's ownership, there would be a moderate to high risk of increased fine and coarse sediment from roads under this alternative.

#### *INDIRECT EFFECTS*

Positive feedback within the stream systems could result from road-related landslides. Should increased coarse sediment supply to streams occur, this sediment would be stored in stream channels downstream from the roads. This storage, or aggradation, would increase the width-to-depth ratio, a significant adverse effect on aquatic habitat and organisms. In addition, streams could respond to the shallower channels by eroding laterally. This could decrease streambank stability and cause numerous small debris slides. In inner gorges, larger failures (debris slides) involving the streambank and the hillslope could occur. Streambank failures and debris slides could cause additional sediment inputs that would cause channel

widening, lateral erosion, and more streambank failure downstream, allowing adverse sediment conditions to persist and possibly worsen.

#### Alternative 2 (Proposed Action/Proposed Project)

The proposed project includes AB1986 provisions which state that the Final HCP shall impose conditions on road-related activities that are no less protective of species or habitat than the provisions contained in the February 27, 1998, "Pre-Permit Application Agreement in Principle." Therefore, the effects analysis is based upon the interim and default aquatic strategies for roads described in Appendix E.

Under this alternative, approximately 400 miles of new roads would be constructed over the term of the proposed HCP. Roads would be managed under the HCP/SYP prescriptions (Appendix E) and would be assessed for sediment delivery potential using *Assessment and Implementation for P.L. Road-Related Sediment Source Inventories and Storm Proofing* (hereafter referred to as "Assessment Plan") (PALCO, 1998, Volume II, Part O). Road construction and maintenance would be

conducted according to the *Handbook on Forest and Ranch Roads* (Weaver and Hagans, 1994; herein referred to as "Road Guidelines"). These road guidelines are also summarized in PALCO (1998, Volume II, Part N). The major features of these documents are summarized below.

The Road Guidelines require that many deleterious features of road design will be minimized wherever possible, such as the amount of cut and fill, road width, road gradient, and road runoff concentration. Under road design, the Road Guidelines specify that full bench construction be used for slopes steeper than 60 percent. Full bench construction reduces the risk of landslides related to roads. Road cut banks, road spoils, and slide slopes are also addressed. Road surface drainage (including insloping and outsloping) and stream crossings are addressed. In addition, road maintenance is addressed, including summer dust control, minimizing excess grading, and ditch maintenance.

The Assessment Plan contains additional information on the "road armoring plan." The main crossing failure prevention methods presented in the Road Guidelines include installation of rolling dips in the road surface to prevent catastrophic failure of the road prism, resizing and retrofitting undersized culverts, and installing debris barriers above culvert intakes. The Assessment Plan also describes how sediment sources will be identified and treatments will be prescribed, including erosion control and prevention measures. Measures for "upgrading" and "decommissioning" roads are also described. There is considerable overlap with the Road Guidelines on this subject.

The major sources of road-generated sediment are discussed in the Road Guidelines and/or the Assessment Plan. Together, the two documents are fairly comprehensive in their discussion of road issues.

In addition, there are specific HCP prescriptions and the long-term (47-year) HCP prescriptions which directly and indirectly affect road-related mass wasting (Appendix E). These guidelines are as follows:

1. Roads shall be constructed as single-lane that allow for the safe passage and transportation of equipment with periodic turnouts (road width generally 12 to 14 feet) except as approved by NMFS, FWS, and CDFG.
2. Roads shall be constructed primarily on slopes under 50 percent.
3. Roads shall be located outside RMZs, except for RMZ crossings, which shall be minimized.
4. Roads shall be constructed by outsloping, or maintained with rolling dips (or ditched roads maintained by well-spaced ditch relief system).
5. Avoid construction of roads in high-risk situations (e.g., inner gorge, road alignments crossing unstable terrain, alignments crossing slopes greater than 50 percent, headwater swales unless potential roads and specifications are evaluated by a certified engineering geologist (CEG) and submitted to the agencies with the THP for review in advance of THP pre-harvest inspection.
6. When culverts are proposed for Class I fish-bearing or restorable watercourses, the RPF shall be required to demonstrate that the culvert design will conform to best management practices related to culvert installation including but not limited to:
  - a. Culverts will be sized to provide 100-year peak flow passage using any of the methods approved by the FPRs.
  - b. The company shall contact NMFS, FWS, and CDFG to discuss the installation prior to submission of

THP if it wishes to install the culvert using methods that are not consistent with NMFS' culvert guidelines (currently under development). In such cases, if the notified agencies have concerns regarding such culvert installation, they shall communicate such concerns to the RPF and CDF.

7. No road or landing construction or reconstruction during the winter period or any other time of the year during any of the following conditions:
  - a. During periods of measurable rainfall
  - b. Following any rainfall of one-quarter inch or greater, there shall be a minimum of 48 hours of no measurable rainfall prior to resumption of work activities.
8. Other than at watercourse crossings or crossing approaches, permanent roads utilized in riparian management zones shall be treated by rocking, chip sealing or paving to help prevent loss of road surface material.
9. Roads which utilize an inside ditch shall have ditch relief culverts spaced no greater than the specifications listed in Road Guidelines (Weaver and Hagans, 1994).
10. Where stormproofing has been completed, road use for log hauling will cease when it results in a visible increase in the suspended sediment levels of water that drains from the road surface, or within inboard road ditches, directly into a stream.
11. Where stormproofing is not yet complete, road use shall cease after precipitation is sufficient to generate overland flow off the road or is capable of leaving the road if entrapped. Roads used for hauling shall not resume until 48 hours without any precipitation or until the road surface is dry.

Some issues are not specifically addressed in these guidelines. These issues include quality, quantity, and criteria for road surfacing; prevention of sidecasting of graded materials; and no specific provision for decommissioning older, problem roads that are chronic contributors of sediment. However, the sediment source assessment can identify such roads, and they would be considered for decommissioning.

Because of the extensive road networks on PALCO lands, the above measures cannot be implemented immediately in all watersheds. Treatment sites would be prioritized by a method that evaluates the risk of sediment delivery at each site. The sediment risk assessment would be conducted to determine priority sites within Elk River, Freshwater Creek, Lawrence Creek, and Yager Creek, within the first 10 years (Appendix E). During the second 10 years, the efforts would be conducted in the Van Duzen and Middle Eel HUs. During the third decade, sediment source inventories would be conducted on Larabee, Sequoia, Mattole, Salmon Creek, and Bear HUs. Stormproofing on high and medium risk sites (defined within the Assessment) would be done first, within each of the specified watersheds. Therefore, the most critical sedimentation sites would be treated first. Under the default strategy, any proposed THPs falling outside the priority watersheds would need completed sediment source assessments before approval.

The overall effect on sediment from road mass wasting and stream crossing failure would be a gradual but systematic decrease in the amount of sediment from road and stream crossings. This reduction would occur first in the prioritized HUs mentioned above. Some sediment would still be generated from roads because of sidecast and roadcut failures and stream crossings on roads not yet storm proofed. This sediment could significantly affect streams in some watersheds, particularly

where road density is high and/or stream crossings are numerous (see Section 3.6.2). In addition, given the rate of stormproofing across all of PALCO lands, roads storm proofed early in the HCP planning period may need to be reconstructed before all the roads are storm proofed.

Protection of root strength in Class I and II streambanks would decrease somewhat the risk of debris flows generated by debris slides from streambanks which can affect road crossings. Overall, therefore, the risk of road-related mass wasting would be moderate in the short and mid-term, but would be reduced to low over the long term (30 years). Consequently, the effects of road-related mass wasting are below the threshold of significance for people and property.

In addition to the HCP prescriptions, PALCO would be required to enter into a Section 1603 agreement with CDFG to minimize and mitigate the effects of culverts and stream crossings on fish and wildlife resources. PALCO's proposed 1603 provides specific measures to mitigate effects of culvert and stream crossings (PALCO, 1998, Volume VI, Part E).

Under this alternative, there would be a moderate to high risk of fine and coarse sediment flux from roads while the Assessment Plan and Road Guidelines are being implemented. Because these measures are comprehensive in their treatment of road construction and have a low risk of increased sediment supply, indirect effects would be minimal (see Section 3.8).

Creation of the Reserve would result in decrease in road-related mass wasting in the Elk River HU. Management by the BLM and state would probably include abandonment of unstable or seldom used crossings, along with construction of new, stormproofed crossings. Failure of existing stream crossings would be expected to be minor.

Based on public comments and FESA and CESA issuance criteria, the wildlife agencies consider that additional mitigation would be appropriate to reduce the risk of potential adverse effects. These additional mitigation measures would further reduce the impacts as described in the Draft and Final EIS/EIRs. This additional mitigation is summarized in Section 3.4.3.8. Detailed descriptions of the mitigation measures are provided in Appendix P.

#### Alternative 2a (No Elk River Property)

The effects of this alternative would be identical to those under Alternative 2, except the Elk River HU would have a higher proportion of land managed solely under the FPRs. Thus, there would be a low to moderate risk of mass wasting in this HU, while the remaining property would have a low risk in the long term of effects of landslides on people, property, and the aquatic system. Consequently, the effects of road-related mass wasting are below the threshold of significance for people and property and in relation to indirect effects (see Section 3.8).

#### Alternative 3 (Property-wide Selective Harvest)

Under this alternative, the effects would be the same as those under Alternative 2 because the same road procedures are used outside the Reserve. The number of road crossings and road density are assumed to be similar. In addition, some watersheds would receive extra protection in order to meet a zero net discharge policy. Road failures that are not at stream crossings, such as sidecast failure, would be addressed under this alternative. Therefore, coarse and fine sediment from road-related mass wasting would be reduced under this alternative for people and property. With a low risk of increased sediment supply, indirect effects would be minimal (see Section 3.8).

Creation of the Reserve would result in decrease in road-related mass wasting in the Elk River HU. Management by the BLM and state would probably include abandonment of unstable or seldom used crossings, along with construction of new, stormproofed crossings. Failure of existing stream crossings would be expected to be minor.

#### Alternative 4 (63,000-acre No-harvest Public Reserve)

Depending on the area, this alternative would offer adequate or inadequate protection from road crossing and other road-related failures. Although Alternative 4 sets aside a large Reserve, no provisions are currently specified for abandoned roads. If no such provisions are implemented after Reserve creation, this alternative could cause a short-term increase in road-stream crossing failures in the watersheds within the Reserve. Though specific restoration activities are not part of this alternative, they are intended after acquisition. Not all stream crossings would be short-term effects. Consequently, the mid- to long-term effects in the Reserve should be less than significant and beneficial.

On PALCO lands, considerably less potential would exist for plugging culverts and causing road crossing failures, as streambank protection given by extensive no-harvest buffers would be high, and debris slides along streams would be limited to background levels. The prescriptions applied on PALCO property are exactly the same as under Alternative 2. Sediment risk assessments and road improvements would be applied to the same priority watersheds over the same three-decade timeframe. Under the default strategy, any proposed THPs outside the priority watersheds would need completed sediment source assessments before approval. With a low risk of increased sediment supply, indirect effects would be minimal. Consequently, effects would be

less than significant for people and property. Indirect effects would also be minimal (Section 3.8).

#### 3.6.3.3 Hillslope Erosion

The main practices that affect hillslope surface erosion are tractor logging, burning, and to a lesser extent, cable yarding. The alternatives vary by limitations placed on logging which affect how much sediment delivery is possible through RMZs, as well as by the rate of timber harvest. Other sources of fine sediment, such as road crossing failures, road surface erosion, mass wasting (both from roads and from logged areas), burning, and grazing, are discussed separately.

#### Threshold of Significance

The amount of hillslope erosion is highly site specific, depending on soils, topography, slope, timber harvest method, and harvest unit design. Eroded sediment that reaches streams has a direct effect on water quality. Consequently, the threshold of significance for hillslope erosion is the probability of exceedance of the water quality standards (see Section 3.4). While some hillslope erosion is unavoidable due to the nature of logging operations, the delivery to streams can be mitigated to a less than significant level.

#### Alternative 1 (No Action/No Project)

As noted in Section 2.5 and Section 3.6.3.1, the evaluation of the No Action/No Project differs under CEQA and NEPA. For CEQA the No Action alternative is not projected into the long-term future. In the short term, the conformance with the FPRs, the FESA and CESA, and other federal and state laws is determined on a THP and site-specific basis. Compliance is attained by a wide variety of mitigation measures tailored to local conditions such that significant environmental effects and take of listed species are avoided. Consequently, most significant environmental effects of individual THPs can be expected to be

mitigated to a level of less than significant through implementation of the No Action/No Project alternative.

As noted in Section 2.5 and Section 3.6.3.1, the NEPA evaluation of the No Action alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZs are considered qualitatively because adequate buffer widths could vary as a result of varying conditions on PALCO lands.

Because logging would continue at current levels and under current practices, hillslope compaction and erosion would continue to be a source of fine sediment under Alternative 1. Under existing FPRs, tractor logging is allowed on steep slopes (up to 65 percent away from streams; up to 50 percent adjacent to the RMZ) and would cause a combination of exposure of the mineral soil and compaction, allowing the potential for erosion from rainsplash and runoff. However, a study by Marron et al. (1995) indicated that four years after tractor logging on Hugo and Melbourne soils, two of the most common soils in the Project Area, there was no statistically significant surface erosion. Their study did indicate significant erosion associated with tractor logging on soils developed in schist.

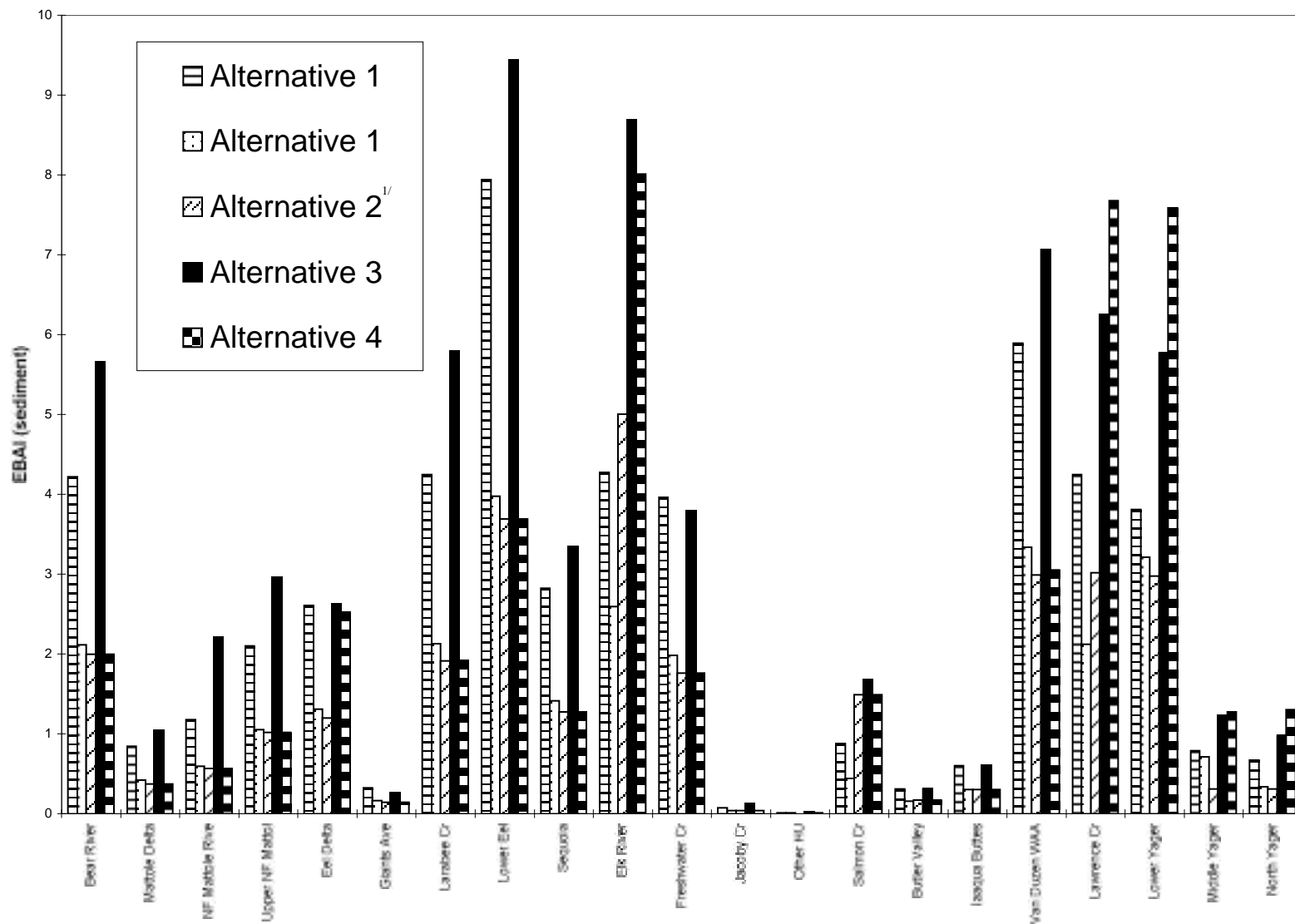
In addition, the buffers on streams under this alternative would be wide enough to filter out all sediment from hillslopes except the clay-sized particles on Class II and III streams. The Equivalent Buffer Area Index (EBAI) was developed as part of this document to evaluate the potential level of sediment filtration provided by various buffers proposed. A detailed description of the EBAI is found in Appendix I. The EBAI uses buffer width and proposed activities within buffers to determine a relative indicator of the buffer's filtration capability. Recommended buffer widths in the literature almost exclusively assume that the buffers are no-

cut buffers. Therefore, the EBAI was developed to take into account the activities allowed within the buffers proposed for each alternative. The EBAI indicates how the alternatives compare in the amount of sediment filtration. Figure 3.6-6 shows the EBAI by watershed for each alternative. Figure 3.6-7 shows the EBAI normalized by stream miles to provide a direct comparison of watersheds for each alternative. Although Alternative 1 has very wide buffers, Alternatives 3 and 4 generally have higher EBAI, which reflects the large amount of protection given by old-growth buffers and Reserve.

Tractor yarding is typically used between 60 and 80 percent of the time on PALCO lands.

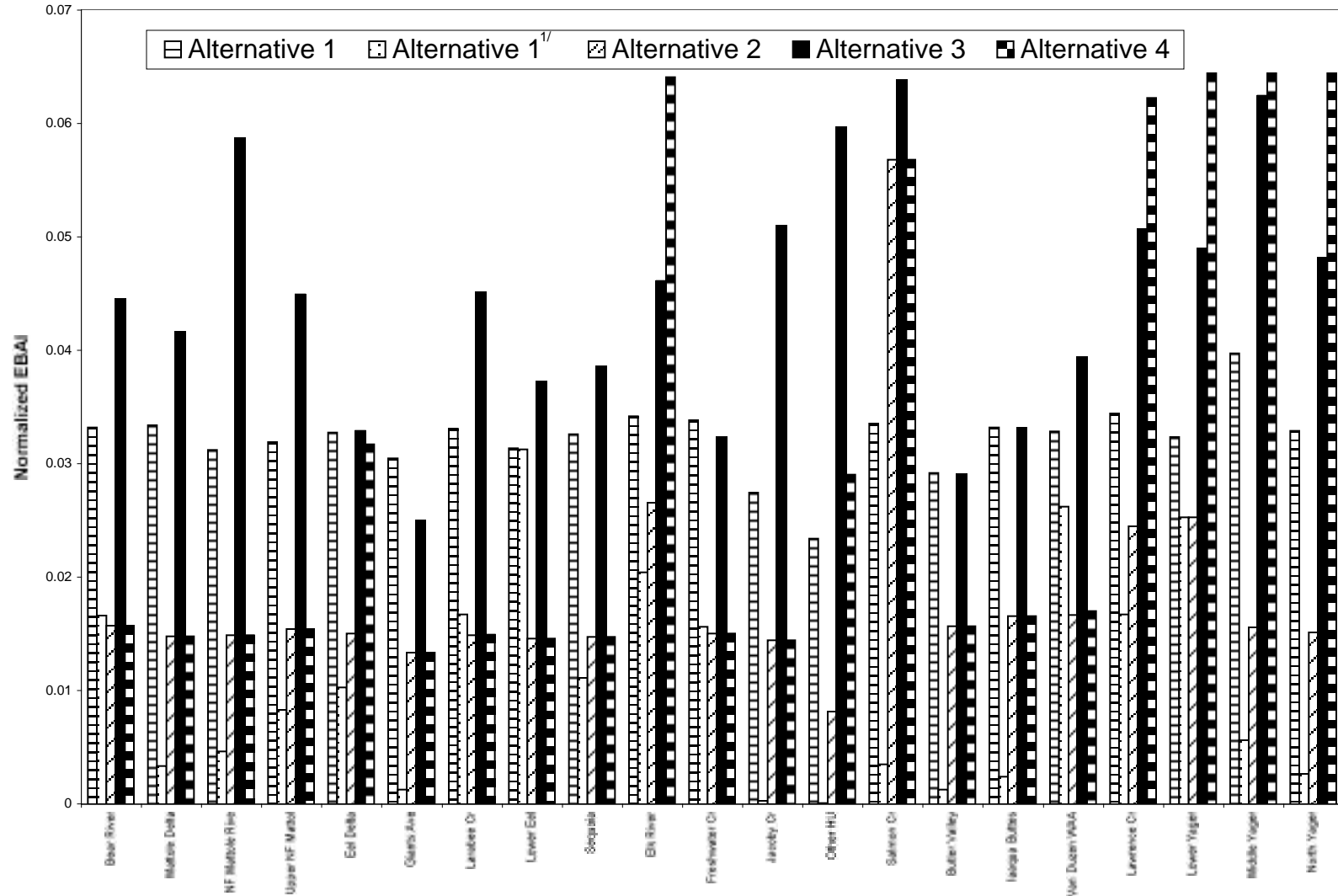
As discussed in Section 3.6.2, tractor yarding can cause surface erosion, rilling, and gullyng. Sediment derived from surface erosion may or may not be delivered to streams, depending on the type of post-harvest treatment and the amount and type of vegetation downslope from an eroding area. Gullyng, if developed, is much more likely to deliver sediment to streams due to greater transport capacity.

Under the existing FPRs, disturbed areas larger than 800 square feet within WLPZs must be treated using erosion control techniques to prevent sediment from entering Class I or II streams. Disturbed areas outside the WLPZ do not require treatment, and no treatment is required adjacent to or upslope from Class III streams. However, under this alternative, no disturbance would occur in the RMZs (except for existing and new road crossings); therefore, there would be no areas requiring treatment in the RMZs and sediment filtration of the RMZs would not be diminished. Requirements for waterbreaks under the FPRs would also diminish surface erosion. Potential rilling and gullyng would be reduced under the existing FPRs due to the requirement of removing tractor crossings of drainages



1/ Calculated using no-harvest buffers of 170 feet, 85 feet, and 50 feet for Class I, Class II, and Class III streams, respectively. In addition, marbled murrelet residual stands are not specifically known and are not accounted for in these values.

**Figure 3.6-6.** Equivalent Buffer Area Index (for sediment) by Alternative



1/ Calculated using no-harvest buffers of 170 feet, 85 feet, and 50 feet for Class I, Class II, and Class III streams, respectively. In addition, marbled murrelet residual stands are not specifically known and are not accounted for in these values.

**Figure 3.6-7. Normalized Equivalent Buffer Area Index by Alternative**

before winter. However, crossings are not always removed before the first rainfall of the wet season, which can result in occasional rilling and gullying (CDF, 1995).

While fire from adjacent broadcast burning may escape and burn the ground cover in the RMZs (Section 3.6.3.6) erosion control measures can be used to minimize the resulting effects on sediment filtration.

In addition, hillslope erosion would be dispersed across the landscape over time. Hillslope surface erosion as a potential source of sediment would probably be higher at a planning watershed level, where much of the area would be harvested in a short time (16 to 24 years). On the whole, risk of fine sediment delivery from hillslope erosion would be low.

#### Alternative 2 (Proposed Action/Proposed Project)

Erosion from hillslopes due to timber harvest would be a minor source of sediment under this alternative. The extensive use of tractor logging and clearcutting, potentially on steep slopes (up to 65 percent; up to 50 percent near streams), would remove the organic layer and/or compact the soil, increase the runoff, and generally expose soils to surface runoff. No-harvest zones on Class I and II streams, however, would substantially filter sediment eroded from hillslopes. Additionally, EEZs on Class I, II, and III streams would decrease direct delivery of sediment from hillslope erosion adjacent to streams. Based on width alone, RMZs would be sufficient to filter most sediment along Class I and II streams, but could be less effective for Class III streams. The EBAI (Figures 3.6-6 and 3.6-7) shows that this alternative provides the least sediment filtration potential of all the alternatives, for all HUs except Elk River and Salmon Creek.

This alternative, however, has prescriptions that specifically limit hillslope erosion. Within RMZs, EEZs, and

ELZs, PALCO would be required to treat areas with greater than 100 square feet of exposed mineral soil regardless of slope, and would be required to treat any exposed soil less than 100 square feet if the slope is greater than 30 percent and delivery to a watercourse is possible. Treatments may include revegetation or other erosion control measures including, but not limited to, seeding and mulching. The threshold area for treatment is very small, only 1/8 of the current standard in the FPRs. Skid trails and cable corridors would have waterbreaks at regular intervals to prevent erosion along their paths. Because of these practices to prevent erosion and provide filtration, risk of fine sediment flux from hillslope erosion would be low to moderate (i.e., less than significant). Note that in the Freshwater and Bear River HUs, Atwell soils are present, which are highly erodible. In these watersheds, there would be more risk of fine sediment influx from hillslope erosion, but the erosion control prescriptions noted above should minimize these effects. In addition, any such effects would be very short term because of the rapid regrowth of vegetation.

#### Alternative 2a (No Elk River Property)

This alternative would be nearly identical to the proposed HCP, with the exception that 9,000 acres in the Elk River HU would receive less protection against hillslope erosion. The effects related to hillslope erosion would be less than significant.

#### Alternative 3 (Property-wide Selective Harvest)

This alternative does not have specific requirements regarding hillslope erosion, and FPRs would be used as a default. Property-wide selective harvest and maintenance of a 20 percent late seral stage forest would minimize the amount of soils exposed to erosion by tractor logging. In addition, RMZs would be effective at filtering most hillslope erosion-generated sediment because of the widths and limits on activities within the RMZs. The EBAI

under Alternative 3 is higher than or equal to other alternatives in every watershed. The EBAI is almost two times that for Alternative 2 in each watershed. Therefore, this alternative would provide the most protection against hillslope erosion. The effects related to hillslope erosion would be less than significant (Section 3.4).

#### Alternative 4 (63,000-acre No-Harvest Public Reserve)

Under this alternative, the timber harvest practices and RMZs would be the same as in Alternative 2. The exclusion of 63,000 acres of no-harvest areas (Headwaters Reserve) from timber harvest would substantially reduce the area over which hillslope erosion would occur. In non-Reserve lands, the same protections for hillslope erosion under Alternative 2 would be used. Protection from hillslope erosion-generated sediment, as described under Alternative 2, would minimize sediment entering most streams. The EBAI under this alternative (see Figures 3.6-6 and 3.6-7) is similar to that for Alternative 2 for every watershed except those which lie within the 63,000-acre reserve. In these watersheds, the EBAI is equal to or greater than the next highest EBAI, which is for Alternative 3. Therefore, this alternative would not cause significant sedimentation related to hillslope erosion (Section 3.4).

##### 3.6.3.4 Road Surface Erosion

As discussed above, road surface erosion is primarily related to traffic levels and surfacing, although cutslope and fillslope erosion can be significant locally. RMZs will not filter out sediment delivered directly to channels and to streams at road crossings. However, roads that are outsloped will drain to the hillslopes where, if sufficient vegetation is present, sediment will drop out before reaching streams. Thus, road building and reconstruction will play a role in the delivery of road surface-generated sediment.

#### Threshold of Significance

While road surface erosion is less dependent on local conditions than other sediment sources, factors of road design and construction vary significantly. The potential for delivery of road sediment must be determined at each site. Also, the distribution of truck traffic in the future is difficult to characterize. Therefore, it is not possible to quantitatively estimate road-generated sediment and its delivery at the scale of the Project Area. The threshold of significance is the probability of exceedance of water quality standards attributable to roads based on an evaluation of the prescriptions contained in each alternative (Section 3.4). Prioritization of road restoration is also a component of systematic reduction in sediment flux due to land management.

#### Alternative 1 (No Action/No Project)

As noted in Section 2.5 and Section 3.6.3.1, the evaluation of the No Action/No Project differs under CEQA and NEPA. For CEQA the No Action alternative is not projected into the long-term future. In the short term, the conformance with the FPRs, the FESA and CESA, and other federal and state laws is determined on a THP and site-specific basis. Compliance is attained by a wide variety of mitigation measures tailored to local conditions such that significant environmental effects and take of listed species are avoided. Consequently, most significant environmental effects of individual THPs can be expected to be mitigated to a level of less than significant through implementation of the No Action/No Project alternative.

As noted in Section 2.5 and Section 3.6.3.1, the NEPA evaluation of the No Action alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZs are considered qualitatively because adequate

buffer widths could vary as a result of varying conditions on PALCO lands.

The FPRs currently protect against road-generated erosion through seasonal restrictions on operations, but there is evidence that this is not always sufficient (CDF, 1995). Treatment of unused legacy roads is not generally required and roads that are adjacent and parallel to streams or are insloped with ditches may contribute sediment directly to streams. Recent sediment surveys in Bear Creek, Elk River, and Stitz Creek identify management-related and natural sediment sources in the Project Area (PWA, 1998). During a recent site visit, several mainline haul roads were observed to have fines “pumping” up through the road bed. Consequently, under this alternative, road-surface generated sediment would continue to be a significant source of fines. Because of the wide distribution of roads, increased road densities and the rate of timber harvest, adverse effects would occur in the short and long term.

#### Alternative 2 (Proposed Action/Proposed Project)

The proposed project includes AB1986 provisions which state that the Final HCP shall impose conditions on road-related activities that are no less protective of species or habitat than the provisions contained in the February 27, 1998, “Pre-Permit Application Agreement in Principle.” Therefore, the effects analysis is based upon the interim and default aquatic strategies for roads described in Appendix E.

Under this alternative, the Assessment Plan and Road Guidelines discussed in Section 3.6.1.2 would be used to evaluate sediment sources, prioritize, and prescribe preventative and/or restorative measures. They would be applied to the priority watersheds in the sequence described for Alternative 2 in Section 3.6.3.2 (Road-related Mass Wasting). The Road

Guidelines contain recommendations for all aspects of erosion control associated with road surface erosion, including road construction, road surfacing, and stream crossings. With implementation of these procedures, road surface erosion would be minimized over time. However, wet weather road use and maintenance and winter road construction may cause significant increases in road-related surface erosion. The HCP states that road use activities will cease when activities result in a visible increase in turbidity in a Class I, Class II, or Class III watercourse, or any drainage facility or road surface that drains directly to a Class I, II, or III watercourse. The cessation of activities once the sediment is being delivered to streams and/or ditches increases the amount of road surface erosion due to continued activity up to the visible increase in turbidity.

The prescriptions for road construction allow new road construction and stormproofing during the winter period (November 1 to April 1). Road construction would not occur during periods of measurable precipitation. Road building in the winter months is contingent upon CDF approval (for THP-related roads only) and the notification to NMFS, FWS and CDFG of the road construction activities. In the absence of adequate mitigation, however, the exposure of road fill material and disturbed soil during the heavy rains of winter could result in excessive discharge of sediment to streams, violating water quality objectives for sediment and turbidity. The winter road management prescriptions could result in adverse impacts, present a high risk to water quality and its beneficial uses, and exceed the threshold of significance for sediment discharge. The federal and state agencies and PALCO have, however, agreed to develop a process where specific, identified road-related activities to address emergencies and special circumstances could proceed without prior approval, such

as responding to culvert failures and other circumstances that could otherwise result in ongoing sediment discharges. These would enable faster response to minimize discharges. Assuming that all other winter road construction or reconstruction activities and stormproofing, other than those specific activities identified for emergencies and special circumstances, were allowed only after approval by CDF, NMFS, FWS, and CDFG (in order to avoid excess sediment discharges), the risk to water quality and its beneficial uses would be less than significant.

In addition, the wet weather road use prescriptions in the HCP present a moderate risk to water quality. This risk has been minimized to a level of less than significant because the HCP requires that road use activities cease when activities result in a visible increase in turbidity in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse, or a visible increase in turbidity in any Class I, II, or III watercourse.

In the Reserve, road surface erosion would be less than significant due to the relative lack of traffic. Although some road traffic would be expected from visitors to the Reserve, passenger vehicles and light trucks along with continued road maintenance produce much less road surface erosion.

Based on public comments and FESA and CESA issuance criteria, the wildlife agencies consider that additional mitigation would be appropriate to reduce the risk of potential adverse effects. These additional mitigation measures would further reduce the impacts as described in the Draft and Final EIS/EIRs. This additional mitigation is summarized in Section 3.4.3.8. Detailed descriptions of the mitigation measures are provided in Appendix P.

#### Alternative 2a (No Elk River Property)

In all areas except those owned by Elk River Timber Company, effects of road surface erosion would be the same as Alternative 2 (i.e., less than significant; see Section 3.4). In the Reserve, the effects would be the same as discussed for Alternative 2, although the area affected would be slightly smaller.

#### Alternative 3 (Property-wide Selective Harvest)

Under this alternative, several different aspects would contribute to a low risk of road-generated sediment delivery. Wide no-harvest buffers would provide adequate filtration for most sediment delivered from out-sloped roads. For in-sloped roads with ditches, the recommendations contained in the Road Guidelines would, over time, minimize road erosion and thus sediment delivery. Additionally, truck traffic would likely be reduced relative to Alternative 2, since much more of the PALCO ownership would be in non-harvestable reserves (old growth and buffers). Because of selective harvest, the rate of timber harvest and truck traffic would be considerably less than under Alternatives 1 and 2. Specific treatment of road erosion in the cumulatively impacted Freshwater, Elk River, Lower Eel, Bear Creek, and Jordan Creek watersheds would provide immediate benefits in sediment reduction. Therefore, long-term effects of road surface erosion would be minimal and less than significant under this alternative (Section 3.4).

Effects within the Reserve would be the same as under Alternative 2.

#### Alternative 4 (63,000-acre No-harvest Public Reserve)

While the effects on road-generated sediment are generally the same as Alternative 2, the Lawrence Creek, Lower Yager, and North, Middle, and Lower Yager HUs would show a steep drop in

road surface-generated sediment, since very few trucks or cars would be driving roads in the 63,000-acre Reserve. Combined with the no-harvest portions of RMZs, the effects of road-generated sediment would be less than significant (Section 3.4).

#### 3.6.3.5 Soil Productivity

The primary variables used to evaluate the effects on soil productivity were (1) amount of timber harvest; (2) amount of tractor logging; (3) intensity of broadcast burning; and (4) rotation period. Effects of timber harvest on soil productivity are primarily long term and result from the combination of the above factors. Decreases in soil productivity directly affect timber volumes, although this effect may not be observed for decades. A brief description of the direct effects on soil productivity is given below. The long-term cumulative effects are discussed under Section 3.6.5, Cumulative Effects.

#### Threshold of Significance

A significant effect on soil productivity would be a 10 percent decrease in timber volume due to soil productivity decreases, either due to heavy tractor logging or due to the probability of intense burns from prescribed fires (see Section 3.6.1.6). Standards for skid trail use designed to avoid significant adverse effects on soil productivity are generally about 15 percent of a timber harvest unit (USFS, 1995; Logan and Clinch, 1991; Logan and Clinch, 1993). The potential for productivity decreases is thus based on the likelihood of greater than 15 percent soil disturbance. Significance must also be considered on the basis of the amount of area affected. However, there is no established acreage threshold for decreased soil productivity. It is, therefore, assumed that significant effects would occur if greater than 40 percent of a planning area experiences decreased soil productivity.

#### Alternative 1 (No Action/No Project)

As noted in Section 2.5 and Section 3.6.3.1, the evaluation of the No Action/No Project differs under CEQA and NEPA. For CEQA the No Action alternative is not projected into the long-term future. In the short term, the conformance with the FPRs, the FESA and CESA, and other federal and state laws is determined on a THP and site-specific basis. Compliance is attained by a wide variety of mitigation measures tailored to local conditions such that significant environmental effects and take of listed species are avoided. Consequently, most significant environmental effects of individual THPs can be expected to be mitigated to a level of less than significant through implementation of the No Action/No Project alternative.

As noted in Section 2.5 and Section 3.6.3.1, the NEPA evaluation of the No Action alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZs are considered qualitatively because adequate buffer widths could vary as a result of varying conditions on PALCO lands.

The amount of land that is restricted from timber harvest is high under this alternative. There would be no decrease in short- or long-term soil productivity on these areas.

On the remaining lands, the effects of tractor logging on soil compaction, and in turn, soil productivity, could be significant. Since there is essentially no freeze-thaw cycle in the HCP planning area, once soil is compacted by tractors, it stays compacted beyond the first rotation cycle. One pass by a tractor can significantly reduce the pore space in soil. Three passes can cause maximum compaction for a given combination of soil moisture and machine type (Froelich et al., 1980). While partial suspension cable yarding causes some compaction as logs are dragged across the

ground, the area affected is typically much smaller than when tractor yarding is used. During the first decade, the model predicts approximately 40,000 acres would be tractor yarded, with the highest amount occurring in the Humboldt Bay and Eel WAAs. For the duration of the HCP planning period, the model predicts the amount of tractor logging on a property-wide basis would range between 11,500 and 19,000 acres per decade. Tractor logging would constitute 80 percent of the total harvest (Table 3.9-7). However, not all of the PALCO landscape is harvestable (i.e., grasslands and buffers). There is no quantitative limit on skid trail areas under the FPRs. The amount of compaction will depend on how efficiently skid trails are planned and used. Since tractor logging can cause significant amounts of compaction, this alternative could result in locally significant effects on soil productivity. Mitigation methods can alleviate or minimize soil compaction, although some compaction and erosion cannot be avoided, due to the nature of timber harvest methods. Such mitigation could include flagging of skid trails before logging operations begin; using only smaller, narrower skidding equipment (thereby minimizing the width of disturbance and compaction); and designing skid trails to minimize their total area. Potential loss of productivity due to soil effects would also be more than offset by management practices that increase growth rates. These management practices include planting of seedlings and control of stocking density.

Broadcast burning is generally less intense (and less destructive) than slash pile burning, although slash pile burning affects a much smaller area. Under this alternative, some nutrients would be lost to volatilization during broadcast burning, and some would be lost by leaching shortly after burning. Only under unusually hot conditions would broadcast burning be hot enough to volatilize significant amounts of

nitrogen. As long as broadcast burning is used and is not practiced during extremely hot weather, no adverse effects on soil productivity would be expected.

#### Alternative 2 (Proposed Action/Proposed Project)

Under this alternative, up to 53,000 acres of PALCO land would be tractor logged during a given decade. Based on inspection of recent aerial photographs, up to 40 to 60 percent of the surface is disturbed by tractor yarding. Assuming compaction occurs on 80 percent of this area, as much as 25,000 acres of soil could be compacted in one decade.

There are no differences in broadcast burning between Alternatives 1 and 2. Therefore, the effect of broadcast burning on soil productivity would not be significant.

Under this alternative, the localized effects of compaction on soil productivity would be the same as under Alternative 1. However, a large portion of PALCO lands would not be harvested under this alternative, as they fall within RMZs and MMCAs and their buffers. The potential local loss of productivity would also be offset by PALCO's proposed management practices, which would increase tree growth rates. These management practices include site preparation, planting of seedlings, vegetation control, and precommercial thinning (PALCO, 1998, Volumes I and III, Part G). Consequently, while there may be locally significant effects on soil productivity, on a larger scale these effects are less than significant.

#### Alternative 3 (Property-wide Selective Harvest)

Under this alternative, there would be some potential for loss of soil productivity if the selective timber harvest was done by tractor logging. This potential exists because of the need for more frequent passes over the same skid trails than in

Alternatives 1 and 2. Use of skid trails would occur more frequently because of the lack of clearcutting. With clearcutting silvicultural prescriptions, stands might not be entered for another 50 years, providing some time for soil compaction to be reduced. With selective harvesting this rest period would be less. The potential level of repeated passes would be reduced because of the lower levels of timber harvest that occur overall under this alternative. These effects would also be mitigated to some degree by the increased growth that would occur in the trees left in particular stands (i.e., the effects would be similar to pre-commercial thinning). Though there would be locally significant effects on soil productivity, on a larger scale these effects would be less than significant.

#### Alternative 4 (63,000-acre No-harvest Public Reserve)

The effects of this alternative on soil productivity outside the Reserve would be exactly the same as for Alternative 2 because the proposed HCP would apply in those areas. There would be localized effects of compaction on soil productivity. However, this potential loss of soil productivity would be offset by PALCO's proposed management practices which would increase tree growth rates. These management practices include site preparation, planting of seedlings, vegetation control, and precommercial thinning (PALCO, 1998, Volume I; Volume II, Part G). Consequently, while there may be locally significant effects to soil productivity on PALCO lands, on a larger scale these effects are less than significant. In the Reserve, there would be no potential for loss of soil productivity.

#### 3.6.3.6 Effects of Fire

##### Threshold of Significance

Fire can cause decreased soil productivity, increase erosion and runoff (McNabb and Swanson, 1990), and decrease the

effectiveness of buffers for filtering sediment. Effects of fire on soil productivity are described in Section 3.6.3.5, above. This section will discuss the two latter effects.

As with effects on soil productivity, the intensity of broadcast burning determines if there is an effect. The recovery time of soil and vegetation also plays a role in determining significance. If fire-related effects are locally significant but short-lived, the effect would never be widespread across a watershed, and would not be significant at a large scale. In addition, even where fires are intense, water-repellent layers have been shown to have no effect after 25 years. Therefore, the main potential effect of fire in the Project Area is on the RMZs.

The threshold for effects related to fire is the potential for more complete burning of the forest understory on more than 20 percent of RMZs in a given watershed within 10 years. Above this threshold, significant amounts of sediment could reach streams due to erosion of timber harvest sites adjacent to RMZs, and the lack of sediment filtration within the RMZ.

#### Alternatives 1 (No Action/No Project), 2 (Proposed Action/Proposed Project), and 2a (No Elk River Property)

As noted in Section 2.5 and Section 3.6.3.1, the evaluation of the No Action/No Project differs under CEQA and NEPA. For CEQA the No Action alternative is not projected into the long-term future. In the short term, the conformance with the FPRs, the FESA and CESA, and other federal and state laws is determined on a THP and site-specific basis. Compliance is attained by a wide variety of mitigation measures tailored to local conditions such that significant environmental effects and take of listed species are avoided. Consequently, most significant environmental effects of individual THPs can be expected to be mitigated to a level of less than significant

through implementation of the No Action/No Project alternative.

As noted in Section 2.5 and Section 3.6.3.1, the NEPA evaluation of the No Action alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZs are considered qualitatively because adequate buffer widths could vary as a result of varying conditions on PALCO lands.

Under these alternatives, a large area would be harvested, and thus burned, within the first 10 years. Most of the broadcast burning would occur on sites that were previously second growth, reducing the amount of debris available on the ground for burning. Lightly burned sites can also become revegetated with brush in a few years. Decreases in the sediment filtration capacity of some RMZs would occur, but would likely affect only short segments of the stream where fire escaped into the RMZ. It is assumed that if fire jumped from the understory to the crown of the RMZ, that PALCO would initiate fire suppression actions, minimizing large-scale adverse effects.

Additional mitigation to minimize local effects on RMZs could be applied that would minimize the effects of fire (see Section 3.6.3.5).

#### Alternative 3 (Property-wide Selective Harvest)

Broadcast burning generally is not used with selective harvest. Therefore, there would be no effects from broadcast burning under this alternative, which calls for selective harvest as the exclusive silvicultural system.

#### Alternative 4 (63,000-acre No-harvest Public Reserve)

The effects of burning under this alternative would be similar to those under Alternative 2, except that there would be

no risk of fire-related resource damage within the Reserve, which would be slightly more than one-quarter of PALCO property. The potential effects would be less than significant.

#### 3.6.3.7 Effects of Grazing

##### Threshold of Significance

Livestock grazing may impair water quality and damage riparian zones with degradation of aquatic and wildlife habitats through increases of inorganic and organic sediments and bacterial contaminants (fecal coliform) to the water, and by the physical alteration of riparian and instream habitats. Generally, stream channels in grazed areas contain more fine sediment, streambanks are less stable, banks are less undercut, and summer water temperatures are higher than in ungrazed areas (Armour, 1977; Benke and Zarn, 1976; Platts, 1991). These factors can create unsafe drinking water for humans, and can impair a stream's ability to produce and maintain fish.

Terrestrial habitats can be impacted by modifying plant biomass, species composition, and structural components such as vegetation height and cover. The degree of competition impacts is generally affected by forage availability and animal distribution patterns (Severson and Medina, 1983). Changes in structure and composition of vegetation can also affect invertebrate, avian, and small-mammals populations through habitat and food base alteration (Reynolds and Trost, 1980; Leopold, 1977; Armour et al., 1991).

This section will discuss the impacts on water quality and stream channels from grazing. Impacts on wildlife and fish species, riparian, and wetland habitats from grazing and the associated thresholds of significance are discussed in Sections 3.7 and 3.10.

The threshold of significance for grazing effects was determined to be the risk of

exceeding water quality standards for turbidity, fecal coliform, or fish habitat or for significantly altering channel morphology in at least 1,000 feet of a stream.

#### Grazing (All Alternatives)

Under Alternatives 1 and 3, cattle grazing pressure would remain consistent with current use. Due to relatively low grazing pressure, the patchy distribution of parcels, and the physical features that limit cattle access to wet areas, less than significant effects probably would occur to water quality and the aquatic system under these alternatives. Localized significant impacts to water quality and the aquatic ecosystems may occur in portions of the leased lands where there is less than six acres per animal management unit (AMU) such as Moore's Prairie, Townsend Ranch, Casacca Ranch, Yager Camp, Corbett Ranch, and Bowlby Piece (total 264 acres) (Table 3.6-6). Additionally, minor impacts may occur in the South Rainbow Ranch (1,800 acres) and the Chase Ranch leased property (1,200 acres). These areas are characterized by steep terrain and contain major creeks, some of which flow into the Mattole River. Due to cattle's avoidance of steep terrain, and their tendency to congregate in riparian and wetland habitats, streams and wetland habitats within these areas may be somewhat degraded due to vegetation alteration, channel bank widening, and channel aggradation.

Under the proposed HCP (Alternatives 2 and 4) grazing pressure may be increased from its current level of 600 head to 1,000 head at any one time during the term of the ITPs (PALCO HCP, 1998). Although the distribution of the additional head of cattle would likely not be uniform across PALCO's parcels, overall, grazing pressure would increase from 9.5 to 5.8 acres per head of cattle. Due to the increase in cattle pressure, localized significant impacts to water quality and the aquatic ecosystem

may occur in portions of the leased lands, especially to areas that currently have less than 6 acres per head of cattle (see Alternatives 1 and 3 in this section). However, ranches usually try to keep cattle away from creeks due to possible serious injuries or deaths from cattle falling down steep gradient channels. Ranchers limit cattle access to streams via fences, and by locating salt and developed watering facilities up in pastures to lure the cattle away from riparian areas.

PALCO does not propose new mitigation measures under its HCP.

#### 3.6.4 Summary of Overall Effects by Alternative

Thus far, the effects of individual forest practices have been examined for their contribution to environmental effects. To assist in comparing the alternatives, these contributions are summarized in terms of the hazards that they create. There are three primary hazard categories under soils and geomorphology: fine sediment, coarse sediment, and soil productivity. Table 3.6-5 shows the relationship between the various management practices and processes in these three parameters. The specific effects of these hazards have been discussed in prior sections, and the biological effects of fine and coarse sediment are discussed further in Sections 3.4 and 3.8. Table 3.6-4 shows the combined results of each alternative regarding their effect on fine sediment, coarse sediment, and soil productivity.

##### 3.6.4.1 Alternative 1 (No Action/No Project)

As noted in Section 2.5 and Section 3.6.3.1, the evaluation of the No Action/No Project differs under CEQA and NEPA. For CEQA the No Action alternative is not projected into the long-term future. In the short term, the conformance with the FPRs, the FESA and CESA, and other federal and state laws is determined on a THP and

**Table 3.6-6. Grazing Leases and Associated Characteristics**

<b>Site Name</b>	<b>Acres Leased</b>	<b>Head Grazed</b>	<b>Number of Acres per AMU</b>	<b>Riparian Area Present</b>	<b>Habitat</b>	<b>Fenced</b>
Yager Camp	12	<10	0.1-1.3	Fenced to prevent cattle from getting into Yager Creek when any are present.	Flat pasture	Yes
Corbett Ranch	23	<10	0.1-2.5	Creek (fish bearing)-trib. to Van Duzen. Few cattle, if any.	Flat pasture	Yes
Riverside Acres	30	Unknown	Unknown	Primarily used for horse grazing and growing hay.	Flat pasture	Yes
Moore's Prairie	160	30-40	4-5.3 acre	Spring (dry in summer)	Parcel is located away from any river or fish bearing stream.	Yes
North Rainbow Ranch	830	100	8.3 acre	Spring	High prairie/steep terrain. The area contains many steep slopes that keep livestock close to ridge tops and away from watered areas. Springs provide a water source for cattle.	Yes
Chalk Mt.	71	10	7 acre	Spring	High prairie surrounded by timber, cattle tend to stay in prairie.	No
Patmore Cabin	442	30	14.7 acre	Spring	High prairie surrounded by timer.	No
Chase Ranch	1,250	130	9.6 acre	Small Creeks: Some of this acreage is fenced to keep the herds separated and to keep the cattle from the Class I watercourses. In areas not fenced to prevent cattle entry into WLPZs, the steepness of the ground tends to limit movement into creeks.	Pasture/prairie/steep terrain	No
Bowlby Piece	40	20	2.0 acre	No	Fenced in high prairie piece. Water is provided by a well.	Yes
Moore Ranch	200	30	6.6 acre	Spring		Yes

**Table 3.6-6. Grazing Leases and Associated Characteristics**

<b>Site Name</b>	<b>Acres Leased</b>	<b>Head Grazed</b>	<b>Number of Acres per AMU</b>	<b>Riparian Area Present</b>	<b>Habitat</b>	<b>Fenced</b>
Schmidbauer Ranch	350	None Yet		Spring	Fenced in high prairie piece.	Yes
Casacca Ranch	24	30 yearlings (single cow)	0.8 acre	Unknown	Cattle do not have access to watercourse from PL's property.	Yes
Townsend Ranch	100	20	5.0 acre	Spring	Midslope piece surrounded by forest. Cattle tend to stay in open areas. Water is provided by a spring.	No
Hartman Ranch	450	40	11.25 acre	Spring	Fenced in high prairie piece. Water is provided by a spring.	Yes
South Rainbow Ranch	1,797	100	18 acre	Creek (fish bearing)-Trib. To Mattole	Pasture/prairie/steep terrain. Cattle can access streams in several places. This area has many roads that run through open land mixed with timber. Cattle use the roads to travel between prairie openings, usually crossing watercourses via bridges or culvert crossings. Due to the steepness of this area, the cattle tend to use side hill trails when they are not bale to use a road. Therefore, most crossings of creeks off roads occur at established locations.	No
Source: Foster Wheeler Environmental Corporation						

site-specific basis. Compliance is attained by a wide variety of mitigation measures tailored to local conditions such that significant environmental effects and take of listed species are avoided. Consequently, most significant environmental effects of individual THPs can be expected to be mitigated to a level of less than significant through implementation of the No Action/No Project alternative.

As noted in Section 2.5 and Section 3.6.3.1, the NEPA evaluation of the No Action alternative considers the implementation of wide, no-harvest RMZs as well as restrictions on the harvest of old-growth redwood forest to model conditions over the short and long term. Ranges of RMZs are considered qualitatively because buffer widths could vary as a result of varying conditions on PALCO lands. While Alternative 1 has the most protective stream buffers, it contains few explicit measures for protection from fine and coarse sediment. For those fine sediment from hillslope sources, this alternative has no significant effect because the filtering through RMZs would be sufficient to remove most sediment. However, road surface erosion (mainly in winter) is a significant contributor of fine sediment. There is no explicit measure to prevent road surface erosion, either through reduced traffic during rainfall, or through improved surfacing. It is not certain whether road- and timber harvest-related failures are a significant source of fine sediment, although they are assumed to be significant sources of coarse sediment (see next paragraph). Thus, even if fine sediment from hillslope erosion is filtered out, the more significant source of road crossing failures remains, and the risk of fine sedimentation would be moderate.

Coarse sediment would continue to affect streams, since the roads which are currently a source of coarse sediment would be maintained similar to current conditions. Timber harvest-related mass wasting would remain a moderate potential

source of coarse sediment. Buffers may not be wide enough to prevent landslides from reaching streams, especially Class III streams, which are usually located in steeper areas more prone to mass wasting than Class I and II streams. Landslides along Class III streams could be a significant source of coarse sediment, given the high proportion of PALCO's property that is underlain by landslide-related features. The overall risk for coarse sediment delivery would be moderate to high. The indirect effects described above would be significant, particularly during large storm events such as the 25-year or 50-year flood.

Soil productivity effects would not change substantially over the long term because of the offsetting effects of improved management practices such as tree planting and precommercial thinning.

#### 3.6.4.2 Alternative 2 (Proposed Action/Proposed Project)

This alternative would provide some protection from fine sediment, including substantial RMZs on Class I and II streams. Additional protection would be given through marbled murrelet habitat protection. However, Class III streams would still provide short-term intermittent pathways for fine sediment. Other erosion control methods, however, would minimize these effects. Additionally, after the individual harvest units revegetate (about five years), there would be no sediment supplied. Road traffic is also restricted during wet weather, further reducing sediment input. Outsloping of roads and water bars would also reduce erosion in many areas. Therefore, the risk of fine sedimentation would be low to moderate.

Coarse sediment from mass wasting would be diminished relative to current conditions. More consideration for timber harvest-related landslides would be given, and the road stormproofing plan would substantially reduce stream crossing

failures. In the short term, while this plan is still being implemented, there would be some coarse sediment inputs during large storms. In the long term, however, the risk of excess coarse sediment inputs would be low to moderate.

Effects on soil productivity would be less than significant because of the existing and proposed management practices such as vegetation control, planting, and precommercial thinning.

#### 3.6.4.3 Alternative 2a (No Elk River Property)

Alternative 2a would have the same effects as Alternative 2, except that Elk River Timber Company lands would be managed as described under Alternative 1. The effects on these lands, therefore, would be similar to those described for that alternative.

As in Alternative 2, soil productivity effects would be less than significant.

#### 3.6.4.4 Alternative 3 (Property-wide Selective Harvest)

This alternative would have low risk of fine and coarse sediment inputs over the long term, mostly because the incidental protection from large buffers, old-growth areas of associated buffers, would reduce logging operations in general. Selective harvest should greatly reduce timber harvest-related mass wasting, and road stormproofing would decrease road crossing failures.

Effects on soil productivity would be less than significant. This is because only a small portion of the ownership would be harvested, and cable yarding would be used. In addition, this effect would be widely dispersed.

#### 3.6.4.5 Alternative 4 (63,000-acre No-harvest Public Reserve)

This alternative is similar to Alternative 2. However, the Reserve would be much

larger, and the effects of timber harvest would occur over a smaller area. All potential timber harvest effects in the Reserve would be greatly reduced relative to existing conditions. The hydrologic units in the 63,000-acre reserve would gradually recover from past timber harvest-related effects, although a short-term increase in sediment could occur due to diminished road maintenance.

On non-Reserve lands, land management prescriptions would be the same as under Alternative 2. Therefore, there would be a low to moderate risk of coarse and fine sediment inputs in the long term.

Soil productivity would not be affected in the Reserve; on the remainder of the ownership, the effects would be similar to those under Alternative 2. Therefore, there could be significant effects on soil productivity.

#### 3.6.4.6 Mitigation

In the Draft HCP, the applicant provided suggested minimization and mitigation measures that have been analyzed in the Draft EIS/EIR and, for CEQA purposes, in the Final EIS/EIR as resulting in less than significant effects to affected resources except with respect to wet-weather road use and winter road construction and reconstruction activities. However, after reviewing and evaluating public comments on the Draft EIS/EIR in light of FESA and CESA permit issuance criteria, the wildlife agencies have determined that additional measures are appropriate to minimize and fully mitigate the impacts of take and to further reduce potential adverse effects. The complete package of minimization and mitigation measures is presented in the proposed HCP's Operating Conservation Program in Appendix P. The additional mitigation measures are intended to further reduce the delivery of road- and timber-harvest-related sediment to the drainage network to protect beneficial uses of the water, including aquatic habitat.

These measures also reduce the effects of wet-weather road use and winter road construction and reconstruction to less than significant. Additional mitigation has been added for the following:

1. Sediment assessment
2. Road stormproofing
3. Road construction, reconstruction, and improvement
4. Road inspections
5. Wet weather road use restrictions
6. Hillslope management
7. Riparian buffers

A summary of the additional mitigation is presented in Section 3.4.3.8.

### 3.6.5 Cumulative Effects

#### 3.6.5.1 Introduction

The Proposed Action would affect watersheds in the planning area over a 50-year period. In general, it is directed at providing listed terrestrial and aquatic species with the habitat conditions needed to maintain viable populations while implementing the SYP. Aquatic habitat is sensitive to activities in the upslope and riparian areas. Key components in the watershed that affect aquatic habitat include fine and coarse sediment influxes and channel morphology. Implementation of the proposed HCP would generally improve conditions for all of these parameters.

Cumulative watershed effects of the Proposed Action/Proposed Project were evaluated at the individual watershed level because most effects would be contained within this boundary or areas downstream. The two main factors that were considered in the evaluation included the following:

1. The percentage of PALCO ownership in an individual watershed (Table 3.6-7)

2. Land uses (and ownership) authorized by county plans (Table 3.6-8)

Prescriptions under the Proposed Action/Proposed Project such as requirements for RMZs and road management would be implemented across the Project Area. The designation of the Headwaters Reserve would involve full protection of natural resources. In general the percentage of PALCO ownership in an individual watershed was used to determine the potential cumulative effect of the Proposed Action/Proposed Project. The smaller the area owned by PALCO in a watershed (or otherwise affected by the Proposed Action/Proposed Project), the smaller the potential for cumulative effects. For example, the Proposed Action/Proposed Project would likely have minimal cumulative effects on the Mad River watershed because PALCO owns only 1.2 percent of this watershed. In contrast, PALCO owns about 40 percent of the land in the Yager watershed (Table 3.6-7). Therefore, the Proposed Action/Proposed Project would affect a major portion of this watershed.

Land use on non-PALCO lands is also important in evaluating the cumulative effects of the Proposed Action/Proposed Project within a watershed. For example, private timberlands would be managed under FPRs and new CDF coho considerations guidelines (CDF, 1997b) and federal National Forest System or BLM lands would be managed under the Aquatic Conservation Strategy of the Northwest Forest Plan. Other land uses such as agriculture, grazing, and rural community would also have effects on the watersheds.

The cumulative effects of Alternative 3 would be more beneficial, but also similar to Alternative 2 discussed below. The less intensive land management and sediment reduction plan would, over a 50-year period, decrease management-related sediment delivery (e.g., surface erosion and

**Table 3.6-7. PALCO Ownership Within Overall Watersheds**

<b>Watershed</b>	<b>Hydrologic Unit</b>	<b>Total Acres</b>	<b>%PALCO</b>	<b>Other Owners</b>
Bear	Bear River	66,295	24.9%	75.1%
<i>Bear Total</i>		<i>66,295</i>	<i>24.9%</i>	<i>75.1%</i>
Mattole	Lost Coast	41,419	0.0%	100.0%
	Mattole Delta	56,471	6.9%	93.1%
	Middle Mattole	54,967	0.1%	99.9%
	NF Mattole River	22,765	23.4%	76.6%
	Upper Mattole	45,470	0.0%	100.0%
	Upper NF Mattole	17,502	50.2%	49.8%
<i>Mattole Total</i>		<i>238,595</i>	<i>7.5%</i>	<i>92.5%</i>
Eel	Eel Delta	91,612	11.6%	88.4%
	Giants Ave	132,969	1.7%	98.3%
	Larabee Cr	56,370	26.6%	73.4%
	Lower Eel	44,266	81.4%	18.6%
	Sequoia	100,956	11.5%	88.5%
	(blank)	1,654,027	0.0%	100.0%
<i>Eel Total</i>		<i>2,080,201</i>	<i>3.6%</i>	<i>96.4%</i>
Humboldt Bay	Elk River	33,837	65.6%	34.4%
	Freshwater Cr	27,666	55.8%	44.2%
	Jacoby Cr	13,028	2.9%	97.1%
	Other	41,109	0.4%	99.6%
	Salmon Cr	13,001	4.8%	95.2%
<i>Humboldt Bay Total</i>		<i>128,642</i>	<i>30.2%</i>	<i>69.8%</i>
Mad River	Butler Valley	53,098	3.4%	96.6%
	Iaqua Buttes	39,056	5.4%	94.6%
	Lindsey	30,056	0.0%	100.0%
	Mad Delta	37,031	0.0%	100.0%
	Middle Mad	68,292	0.0%	100.0%
	(blank)	104,543	0.0%	100.0%
<i>Mad River Total</i>		<i>332,077</i>	<i>1.2%</i>	<i>98.8%</i>
Van Duzen River	Van Duzen WAA	55,367	45.1%	54.9%
	(blank)	128,034	0.0%	100.0%
<i>Van Duzen River Total</i>		<i>183,402</i>	<i>13.6%</i>	<i>86.4%</i>
Yager Creek	Lawrence Cr	26,926	56.4%	43.6%
	Lower Yager	14,747	97.8%	2.2%
	Middle Yager	12,816	18.7%	81.3%
	North Yager	30,105	7.0%	93.0%
<i>Yager Creek Total</i>		<i>84,594</i>	<i>40.3%</i>	<i>59.7%</i>
Source: Foster Wheeler Environmental Corporation				

**Table 3.6-8. Acreage of Land Ownership and Land Use by Watershed**

Watershed	Hydrologic Unit	Agriculture		Grazing		Community/Developing Area	
		PALCO	Non-PALCO	PALCO	Non-PALCO	PALCO	Non-PALCO
Bear	Bear River	497	40	524	32,426	0	0
<i>Bear Total</i>		<i>497</i>	<i>40</i>	<i>524</i>	<i>32,426</i>	<i>0</i>	<i>0</i>
Mattole River	Mattole Delta	0	3,266	1,473	31,334	0	45
	Middle Mattole	0	21,337	0	5,825	0	0
	NF Mattole River	0	0	474	13,885	0	0
	Upper Mattole	0	10,647	0	0	0	176
	Upper NF Mattole	203	2,938	1,362	3,139	0	0
<i>Mattole River Total</i>		<i>203</i>	<i>38,189</i>	<i>3,309</i>	<i>54,184</i>	<i>0</i>	<i>222</i>
Eel	Eel Delta	0	3,486	201	16,730	676	46,903
	Giants Ave	20	20,848	124	19,435	32	10,613
	Larabee Cr	0	1,498	889	24,757	228	399
	Lower Eel	0	0	366	316	865	4,920
	Sequoia	12	3,613	713	55,496	147	852
	Other	0	44,033	0	428,766	0	187,744
<i>Eel Total</i>		<i>32</i>	<i>73,479</i>	<i>2,293</i>	<i>545,500</i>	<i>1,947</i>	<i>251,430</i>
Humboldt Bay	Elk River	0	0	0	0	980	5,386
	Freshwater Cr	0	0	16	845	2,281	9,886
	Jacoby Cr	0	0	0	0	319	12,506
	Other	0	480	0	0	52	35,592
	Salmon Cr	0	1,210	0	605	0	2,014
<i>Humboldt Bay Total</i>		<i>0</i>	<i>1,690</i>	<i>16</i>	<i>1,450</i>	<i>3,632</i>	<i>65,385</i>
Mad River	Butler Valley	14	2,654	0	5,892	0	391
	Iaqua Buttes	0	768	262	11,027	0	0
	Lindsey	0	0	0	851	0	722
	Mad Delta	0	0	0	528	0	29,366
	Middle Mad	0	6,297	0	17,335	0	1,158
	Other	0	234	0	1	0	59,682
<i>Mad River Total</i>		<i>14</i>	<i>9,952</i>	<i>262</i>	<i>35,633</i>	<i>0</i>	<i>91,319</i>
Van Duzen River	Van Duzen WAA	0	170	68	6,542	2,276	9,580
	Other	0	16,790	0	38,764	0	5,590
<i>Van Duzen River Total</i>		<i>0</i>	<i>16,960</i>	<i>68</i>	<i>45,306</i>	<i>2,276</i>	<i>15,170</i>
Yager Creek	Lawrence Cr	0	174	416	4,316	0	0
	Lower Yager	0	0	0	0	124	12
	Middle Yager	0	0	32	4,398	0	0
	North Yager	0	0	24	25,809	0	0
<i>Yager Creek Total</i>		<i>0</i>	<i>174</i>	<i>472</i>	<i>34,523</i>	<i>124</i>	<i>12</i>
<b>Grand Total</b>		<b>747</b>	<b>140,484</b>	<b>6,945</b>	<b>749,022</b>	<b>7,980</b>	<b>423,537</b>

**Table 3.6-8. Acreage of Land Ownership and Land Use by Watershed**

Watershed	Open space	Public land		Timber Production		Undesignated	Grand Total
	Non-PALCO	PALCO	Non-PALCO	PALCO	Non-PALCO	Non-PALCO	
Bear	0	135	118	15,381	17,148	23	66,295
<i>Bear Total</i>	<i>0</i>	<i>135</i>	<i>118</i>	<i>15,381</i>	<i>17,148</i>	<i>23</i>	<i>66,295</i>
Mattole River	0	0	6,071	2,396	11,624	261	56,471
	0	0	8,996	30	18,513	266	54,967
	0	0	0	4,843	3,563	0	22,765
	0	0	14,433	0	20,213	0	45,470
	0	424	170	6,799	2,466	0	17,502
<i>Mattole River Total</i>	<i>0</i>	<i>424</i>	<i>29,671</i>	<i>14,068</i>	<i>56,379</i>	<i>528</i>	<i>197,176</i>
Eel	0	0	0	9,768	13,826	22	91,612
	0	68	48,015	2,004	31,811	0	132,969
	0	652	3,197	13,239	11,510	0	56,370
	0	364	1,033	34,421	1,981	0	44,266
	0	11	7,564	10,693	21,624	233	100,956
	5,106	0	648,387	0	308,334	31,657	1,654,027
<i>Eel Total</i>	<i>5,106</i>	<i>1,095</i>	<i>708,197</i>	<i>70,125</i>	<i>389,086</i>	<i>31,911</i>	<i>2,080,201</i>
Humboldt Bay	0	0	0	21,225	6,236	11	33,837
	0	0	0	13,129	1,456	51	27,666
	0	0	0	60	139	4	13,028
	0	0	0	105	4,671	209	41,109
	0	0	0	624	8,330	217	13,001
<i>Humboldt Bay Total</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>35,144</i>	<i>20,833</i>	<i>491</i>	<i>128,642</i>
Mad River	0	0	418	1,791	41,939	0	53,098
	0	0	5,896	1,837	19,266	0	39,056
	0	0	0	0	28,483	0	30,056
	0	0	0	0	7,137	0	37,031
	0	0	32,041	0	11,025	436	68,292
	0	0	8,975	0	2,490	31,626	103,007
<i>Mad River Total</i>	<i>0</i>	<i>0</i>	<i>47,329</i>	<i>3,628</i>	<i>110,341</i>	<i>32,063</i>	<i>330,541</i>
Van Duzen River	0	0	0	22,601	14,130	0	55,367
	0	0	45,712	0	18,014	3,165	128,034
<i>Van Duzen River Total</i>	<i>0</i>	<i>0</i>	<i>45,712</i>	<i>22,601</i>	<i>32,144</i>	<i>3,165</i>	<i>183,402</i>
Yager Creek	0	0	0	14,765	7,255	0	26,926
	0	0	0	14,298	312	0	14,747
	0	0	0	2,369	6,017	0	12,816
	0	0	0	2,093	2,179	0	30,105
<i>Yager Creek Total</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>33,525</i>	<i>15,763</i>	<i>0</i>	<i>84,594</i>
<b>Grand Total</b>	<b>5,106</b>	<b>1,655</b>	<b>831,026</b>	<b>194,473</b>	<b>641,693</b>	<b>68,182</b>	<b>3,070,850</b>

Source: Foster Wheeler Environmental Corporation, 1998

mass wasting-related sediment) to streams on PALCO lands. The cumulative effects of Alternative 4 would also be similar to Alternative 2, except that 63,000 acres of PALCO lands would become a no-harvest Reserve in the Humboldt Bay (24,780 acres), Van Duzen (1,330 acres), Yager (33,600 acres), and Eel WAAa (3,970 acres). The Reserve would reduce the potential of management-related sediment delivery to streams

### 3.6.5.2 PALCO Ownership in Planning Area Watersheds

The percentages of PALCO land ownership in each watershed are shown in Table 3.6-7. The percentages are also identified by HU. All non-PALCO ownership (e.g., other timber companies, public lands) was combined into one value per HU and per watershed.

### 3.6.5.3 Land Use Designations and Associated Effects

The land use designations of the watersheds of the Project Area were determined using the Framework Plans for Humboldt and Mendocino counties (Humboldt County, 1994; Mendocino County, 1993). The proportions of land use by watershed are shown in Table 3.6-8 and Figure 3.6-8. Three different counties are involved, and the three different land use codes were merged as follows:

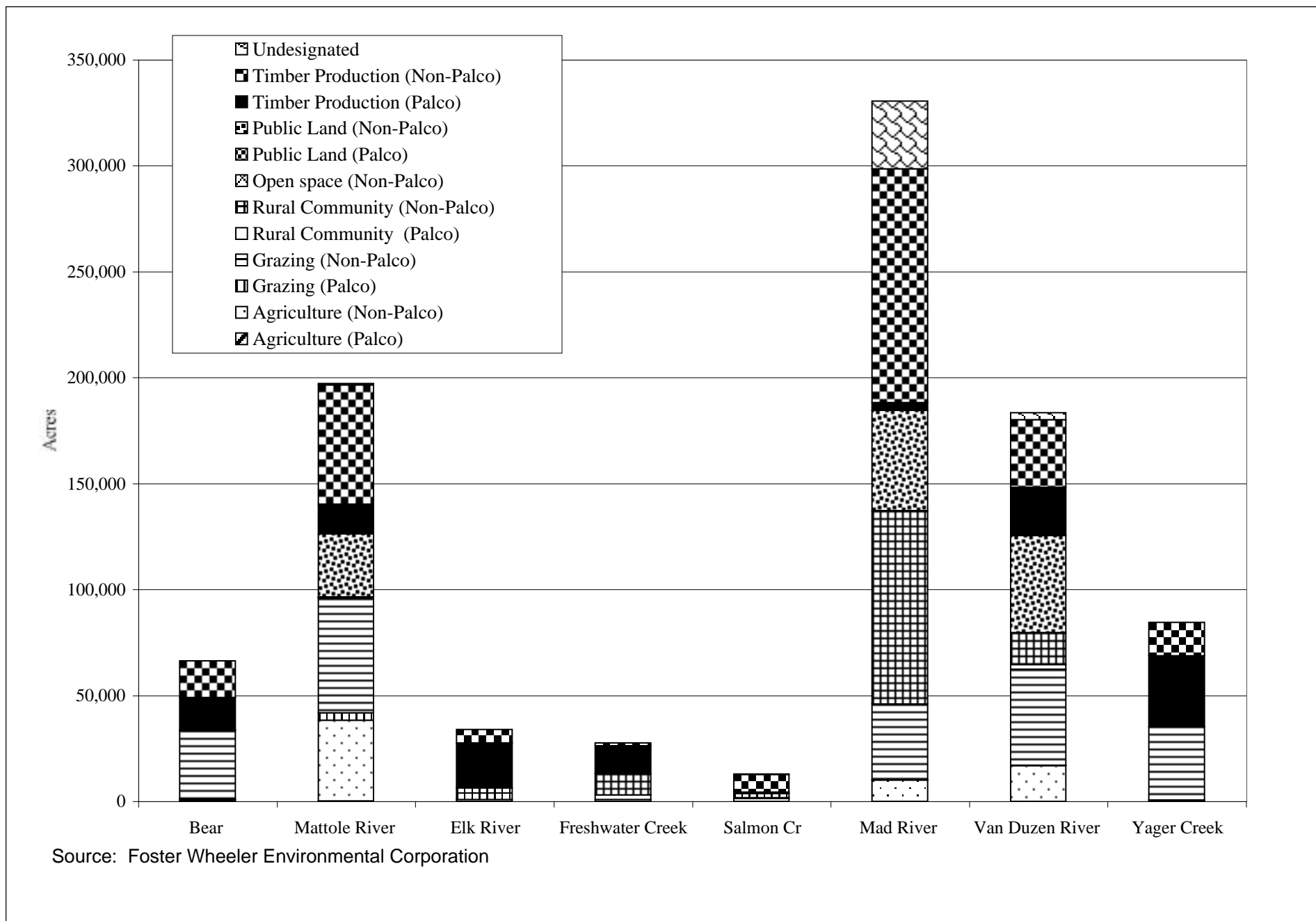
1. Timber Production
2. Agriculture
3. Grazing
4. Rural Community
5. Public Land
6. Open Space

The lands use designations of Trinity County (Trinity County, 1988), applicable to the upper Van Duzen and Eel River watersheds, are somewhat generalized relative to Humboldt and Mendocino counties. The only two designations in Trinity County that are present in the watersheds of interest are "Resource" and

"Rural Residential." The Resource designation includes timber management, mining, and grazing as land uses. For analysis, this designation is assumed to be equivalent to the Timber Production designation of Humboldt and Mendocino counties. Rural Residential is grouped with the Rural Community designation of the other two counties. There is a small area of Open Space designation along the Eel River and some tributaries within Trinity County. This area is grouped with public lands.

All private timberlands are assumed to be managed under FPRs with coho considerations. Combined, these regulations are expected to reduce timber management effects on watershed processes compared to existing practices. The approximate acreage of THPs in Humboldt County are either ongoing or recently completed in the Bear-Mattole (17,000 acres), Eel River (107,000 acres), Humboldt Bay (48,000 acres), Van Duzen (18,000 acres), and Yager WAAs (35,000 acres). These values include PALCO operations. Additionally, other HCPs are being developed that should have similar levels of beneficial effects as the HCP for PALCO lands. Thus, there would be a low-to-moderate risk of fine and coarse sediment increases above background on non-PALCO timberlands. Hydrologic effects would generally be similar to those on PALCO lands, except for higher elevations of the Mad River, Van Duzen, and Eel River watersheds, where some effect from rain-on-snow events is possible, and on public lands, where road densities are likely to be lower than on private lands.

Agricultural lands would be expected to contribute fine sediment, little or no coarse sediment, and have minimal direct hydrologic effects. There are relatively few agricultural areas within the watersheds of the Project Area except in certain HUs in the Mattole watershed. Areas designated for grazing would be expected to experience effects on smaller stream channels. Stream



**Figure 3.6-8.** Land Use Designations in Project Area Wetlands

bank erosion and fine sediment delivery are the primary effects of livestock grazing on aquatic habitat.

Rural community areas include existing development and those areas where future housing development would occur. The most common effects of housing development in a watershed are hardening of streambanks, such as levee construction; increased peak flows due to storm runoff; pulses of increased fine sediment during construction periods; and loss of riparian vegetation due to encroachment on the riparian zone by buildings and infrastructure.

Public lands vary widely in their use of the land. Some public lands in the area have a reserve status, such as Humboldt Redwoods State Park. These areas have virtually no adverse effects on the aquatic system, except for localized effects due to roads, bridges, and trails. National Forest System and BLM lands fall under the public lands category, but in the past have been managed for timber production. As such, effects are assumed to have been similar to past harvest activities on private timberlands. However, since the forested areas on federal lands will be managed according to the Northwest Forest Plan, effects on the aquatic system are expected to diminish in the future.

#### 3.6.5.4 Watersheds

##### Mad River

The proportion of PALCO land within the entire Mad River watershed is less than five percent. It is thus unlikely that the Proposed Action/Proposed Project would have a noticeable cumulative effect, despite the beneficial effects from implementation of the proposed HCP.

##### Freshwater Creek

PALCO owns approximately 56 percent of this watershed. Most of the remainder of the watershed is designated as Rural Community. This designation indicates a

potential for increasing development, although the rate of development is likely to be slow (see Section 3.13, Economic and Social Environment). CDF determined that excessive stream aggradation has occurred and that the watershed is cumulatively impacted by sediment (CDF, 1997b). Consequently, PALCO and other landowners must manage their lands so that management actions do not cause additional sedimentation to occur (CDF, 1997b). TMDLs for sediment would be implemented by the year 2010 (see Section 3.4.3.9, Cumulative Effects). In addition, the prescriptions in the proposed HCP would also reduce fine sediment influx from PALCO lands, channel aggradation, and flooding downstream, and should improve aquatic habitat over time.

##### Elk River

PALCO owns approximately two-thirds of the Elk River watershed. Another 11 percent is designated for timber production. Under the proposed HCP, the Headwaters Reserve would protect approximately 17 miles of stream corridors or about 15 percent of the total stream miles in the watershed. As with Freshwater Creek, CDF determined that excessive stream aggradation has occurred and that the watershed is cumulatively impacted by sediment (CDF, 1997b). In addition, TMDLs for sediment would be implemented by the year 2009 (see Water Quality Cumulative Effects, Section 3.4.3.9). Consequently, PALCO must manage its lands so that its actions do not cause additional sedimentation (CDF, 1997b). In addition, the prescriptions in the proposed HCP, combined with FPRs with coho considerations for other timberlands, would result in improvements in coarse sediment influx, channel aggradation, and flooding potential from these areas.

The remainder of the watershed is designated as rural community (Table 3.6-8). The potential for future habitat

degradation in those areas is low to moderate depending upon the rate of development. The short- and long-term potential for increased fine sediment in the lower reaches of this watershed (primarily non-PALCO lands) is considered low because the current low rate of development and associated disturbances will likely continue. The hydrological effects of development in the lower watershed could compound the cumulative effects already noted by CDF (1997b). Typically, peak flows increase in developing areas as routing of runoff is accelerated. This effect would occur only if a high density of housing develops over the long term. While no effects on coarse sedimentation would be expected from development, the decrease in existing flood storage capacity, coupled with the potential future increased peak flows in the lower watershed, could put the lower reaches of Elk River at risk of scour or lateral channel migration. In the long term, these effects could offset improvements on PALCO lands in the upper watershed that would result from the implementation of the HCP.

#### Salmon Creek

PALCO ownership comprises about 4.8 percent of the Salmon Creek watershed (Figure 3.6-8, Table 3.6-7). It is unlikely that the proposed HCP would have a noticeable cumulative effect on watershed processes and, therefore, on aquatic habitat. The proposed HCP would represent an improvement in fine and coarse sediment delivery to streams, peak flows, channel morphology, and, therefore, in aquatic habitat parameters, over current conditions.

#### Eel River

The area of the Eel River watershed is almost two million acres. Public lands account for approximately 34 percent of the area, which is the highest land use designation in this watershed. PALCO's ownership only accounts for about 6 percent of the watershed, or 3.6 percent if

the Van Duzen River and Yager Creek watersheds are not included (Table 3.6-7). Therefore, it is unlikely that the HCP would have significant cumulative effects on the entire watershed. The proposed HCP would represent a reduction in management-related fine and coarse sediment delivery to streams, as well as improvement in peak flows and channel morphology. In aquatic habitat parameters, therefore, these actions would represent an improvement over current conditions. Consequently, any potential effect would be positive relative to existing conditions. In particular, the sediment delivery from PALCO lands in the Lower Eel HU would decrease over the long term. Bear Creek and Stitz Creek, tributaries to the lower Eel, were designated by CDF as cumulatively affected by sediment. Additional mitigation measures beyond the HCP would be required in these smaller watersheds such that management activities do not cause additional sedimentation to occur (CDF, 1997b).

PALCO's ownership in the Eel River basin includes the Van Duzen River, Yager Creek, and a small area of Eel River drainage. Yager Creek is a tributary to the Van Duzen River, which is a tributary to the Eel River. The Van Duzen River (and its tributary Yager Creek) is considered separately because it joins the Eel River only 12 miles from its mouth. The Van Duzen River, therefore, can only affect the lowermost parts of the Eel River.

#### Van Duzen River

PALCO owns approximately 14 percent of this watershed. The land use designations are 66 percent timber production and about 12 percent grazing. About 21 percent of the watershed is either currently developed or is planned for development.

The proposed HCP would present a low to moderate risk of increase in coarse and fine sediment delivery to streams, and a low risk of peak flows. The non-PALCO timberlands in this watershed would be

managed under FPRs with coho considerations, or according to other HCPs now being developed. In addition, TMDLs for sediment would be implemented by the year 1999 (see Section 3.4.3.9, Cumulative Effects). Therefore, the effects of timber harvest activities on sediment delivery, channel morphology, and hydrology would diminish relative to past conditions, and minimize management-related effects in the long term.

#### Yager Creek /Lawrence Creek

The four HUs within the Yager Creek/Lawrence Creek watershed (Lawrence Creek, Lower Yager, North Yager, and Middle Yager) are considered together. PALCO owns approximately 40 percent of this total watershed (Table 3.6-7).

Land use is 58 percent timber production and 41 percent grazing (Table 3.6-8). Non-PALCO ownership under timber production occupies about 15 percent of the watershed (Figure 3.6-8). Non-PALCO timber production areas are expected to include salmon habitat protection measures from either FPRs with coho considerations or other HCPs at some time in the future. In addition, TMDLs for sediment would be implemented by the year 1999 (see Section 3.4.3.9, Cumulative Effects). These measures should improve conditions for fine and coarse sediment delivery, peak flows, and channel morphology. With approximately half of the watershed used for grazing, the fine and coarse sediment influx is expected to be somewhat lower than for those watersheds designated mostly for timber production. Fine and coarse sediment influx to the aquatic system should decrease over time, although there still may be large amounts of sediment relative to pre-harvest conditions.

#### Bear River

PALCO owns approximately 25 percent of this watershed, mostly in the upper reaches. Overall, land use in the watershed is about evenly divided between

grazing and timber production. Ridge tops in the area are relatively open and grassy, and most grazing occurs there. Any concentrated grazing in riparian areas would be expected to produce moderate amounts of fine sediment and locally alter channel morphology. When combined with the low-to-moderate risk of fine sedimentation under the proposed HCP, existing fine sediment conditions in the lower watershed are likely to continue.

Coarse sediment would be less influenced by grazing. Non-PALCO timber-producing lands (25 percent of the watershed) would be managed under FPRs with coho considerations unless HCPs are developed. The proposed HCP would represent a reduction in management-related coarse sediment delivery to streams, as well as an improvement in peak flows and channel morphology. In aquatic habitat parameters, therefore, these actions would represent an improvement over current conditions. Consequently, any potential effect would be positive relative to existing conditions.

#### Mattole River

PALCO owns approximately nine percent of this watershed. Thirty-six percent of the watershed is designated for timber production. Grazing accounts for an additional 30 percent of land use. Only a small proportion is designated as rural community. Approximately 15 percent of the watershed is on public lands, most of which are federal. The public lands would be managed under the Aquatic Conservation Strategy of the Northwest Forest Plan. Additionally, CDF has adopted a policy of no net discharge of sediment within the Mattole, which would likely keep sediment flux at or below current levels. In addition, TMDLs for sediment would be implemented by the year 2002 (see Section 3.4.3.9, Cumulative Effects). The measures contained within the Aquatic Conservation Strategy, along with those in the proposed HCP and FPRs

with coho considerations, would combine to cause a gradual decrease in coarse sediment influx, which should have some stabilizing effects on channel morphology and assist in the improvement of the aquatic system.

#### 3.6.5.5 Additional Mitigation

After reviewing and evaluating public comments on the Draft EIS/EIR in light of FESA and CESA permit issuance criteria, the wildlife agencies have determined that additional measures are appropriate to

minimize and fully mitigate the impacts of take and to further reduce potential adverse effects. The complete package of minimization and mitigation measures is presented in the proposed HCP's Operating Conservation Program in Appendix P. The additional mitigation measures are intended to reduce the management-related cumulative effects on watershed processes, such as the hydrologic system, the riparian system, and aquatic habitat. The synergistic effects of land management activities are displayed in Figure 3.1-1. The major cumulative effects mitigation is described in Section 3.4.3.10.